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Commoditization of Technology-Based Products and Services: The Base Case Scenarios for Three Industries

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COMMODITIZATION OF TECHNOLOGY-BASED PRODUCTS AND SERVICES:
The Base Case Scenarios for Three Industries

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ABSTRACT

A simulation model is being used to illuminate the principal drivers of commoditization, key differences among industries and markets, leverage points for influencing the dynamics, and strategic responses for corporations contending with commoditization. This report focuses on three markets: air transportation, long distance telecommunications, and refined petroleum products. The development of these markets is analyzed over a thirty-year period. The dynamics of growth, cyclicality, and commoditization in each case are explained. By comparing and contrasting across the three cases significant differences in the drivers of the dynamics and, hence, the long-term performance of the markets are illuminated. These results support the overarching conclusion that commoditization is driven by excess capacity. And they show that complex interactions over time among industry structure (e.g., the fragmentation and internationalization of markets), management policies (e.g., the response of pricing and investment decisions to capacity utilization and profitability), and technology strategy (e.g., the impacts of technology on costs and capabilities) underlie persistent excess capacity and, hence, commoditization. The results also raise significant questions about cause and effect. Does commoditization erode and eventually destroy the incentives and capabilities to innovate? Or is it the consequence of inadequate investment in technology and innovation? The research shows that many factors are ***both*** causes and effects of commoditization. Significant technological progress is very important in mitigating commoditization, by stimulating greater demand, facilitating differentiation, and rewarding aggressive investors. The results raise a provocative conclusion. "Commoditization" easily can be a state of mind. In that case it inevitably becomes ***a self-fulfilling prophesy!***

ACKNOWLEDGEMENTS

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Introduction

"Commoditization" is a fact of life for many technology-based products and services ranging from semi-conductors and personal computers to air transportation, telecommunications, and chemicals. This term is used to denote a competitive environment in which product differentiation is difficult, customer loyalty and brand values are low, and sustainable advantage comes primarily from cost (and often quality) leadership.

The original ICRMOT supported project on "Commoditization of Technology-Based Products and Services" analyzed the dynamics of two service markets, specifically, the US markets for air transportation and long distance telecommunications. A simulation model was used to illuminate:

- The principal drivers of commoditization;
- Key differences among industries and markets;
- Leverage points for influencing the dynamics; and
- Strategic responses for corporations contending with commoditization.

In 1995 a second, parallel ICRMOT supported project "Petroleum Cycles" was launched. This project investigated the causes and strategic implications of cycles in the US market for refined petroleum products. It extended the research to markets which are more mature, complex, and international. Many process industries such as petroleum, chemicals, and metals involve products at advanced stages of commoditization and are notoriously cyclical. The two projects were merged in 1996-97.

The Hong Kong market for mobile telecommunication services is being analyzed as part of the current phase of work. The results should reveal how conditions and decisions in immature high-tech markets affect their later development. The mobile telecommunications case will be the subject of a later report.

This report is the first of a series that presents findings and conclusions from the research. It focuses on the Base Case Scenarios for the first three markets studied, i.e., air transportation, long distance telecommunications, and refined petroleum products. The development of these markets is analyzed over a thirty-year period. The dynamics of growth, cyclicality, and commoditization in each case are explained. By comparing and contrasting across the three cases significant differences in the drivers of the dynamics and, hence, the long-term performance of the markets are illuminated.

Subsequent reports will address results from the mobile telecommunications case study, testing of alternative assumptions and scenarios, and analyses of optimal pricing and capacity investment policies under various market conditions. These reports will be completed over the next six months.

Objectives

The research objectives are first to more clearly define the dynamics of commoditization, and then to identify leverage points whereby a corporation could influence the effects of commoditization on its business performance. Among the specific questions being addressed are:

- How do technological innovations and investments impact the dynamics of commoditization?
- How are the incentives to invest in new capacity and technologies affected?
- How does commoditization alter the character of markets and their cycles?
- How do these cycles relate to the long-term trend in return on capital?
- What are the effects of market liberalization and changes in industry structure?
- Do imports and exports amplify the cycles?
- How should corporate strategy be adjusted to each phase of the dynamics?
- What are the optimal pricing and capacity policies under various market conditions?
- What actions could be taken to anticipate and even influence the future?

The findings are applicable to a wide range of technology-based services and products.

Approach

As described in the Introduction this research involves a series of case studies. The case studies were selected to compare and contrast among different stages of industry/market maturity, liberalization, concentration, and integration. Each case has many similarities with the others but also adds some important new dimensions, for example, with respect to demand growth, technology trends, market structure, and regulatory factors. The markets are at different stages development ranging from immaturity (mobile telecommunications), to early maturity (long distance telephony), to significantly more mature (air transport), to a very advanced stage of commoditization (petroleum products).

A simple, generic, market dynamics model was developed using the System Dynamics methodology. Its details are described in a Working Paper "Commoditization of Technology-

Based Products and Services: A Generic Model of Market Dynamics," March 1996, WP# 144-96. This paper was distributed to all ICRMOT members.

System Dynamics is a powerful methodology for developing and analyzing computer simulation models of complex problems. It has its roots in engineering feedback control systems analysis. The methodology was pioneered at MIT in the 1960s and subsequently has been used by major corporations, government ministries, academic institutions, and research centers around the world. System Dynamics models have contributed to corporate strategy formulation and implementation, analysis of technology-based markets, risk management, and evaluation of government regulations.

The distinguishing features of System Dynamics models are:

- They take a high-level, strategic perspective on problems;
- They embody rich, realistic theories of how the elements of a complex "system" (e.g., a market or individual company) interact to produce its overall behavior;
- They include many behavioral factors (e.g., perceptions, goals, pressures, trade-offs); and
- They integrate in a common framework a wide range of relevant information (e.g., time series data, subjective estimates, direct observations, expert opinions).

System Dynamics models are easily developed and simulated on high-performance personal computers. The generic market dynamics model is programmed in the Vensim simulation language. It will operate on both IBM-compatible and Macintosh platforms.

The generic model was first set up to represent the air transportation market. It next was applied to long distance telecommunications and then to refined petroleum products. Each step required some adaptation of the model. Many cause/effect relationships, parameters, and inputs were changed to capture the specifics of the market and industry being analyzed. In some instances, the model's structure had to be modified.

The original generic model represented a service market and an industry of service providers. In the "Petroleum Cycles" work the model was extensively modified to represent a ***product*** market and industry. For example, the determinants of the production rate were added. In a service industry there is no equivalent decision about how much output to produce. The analogous decision in those industries is how much capacity to offer in a market. Moreover the petroleum version differentiates between high-value refined products (e.g., gasoline, kerosene, and diesel fuel) and low-value products (e.g., residual fuel oil and lubricants) and between technologically advanced capacity and less sophisticated capacity.

Each application of the generic model is very revealing. The required differences in inputs, parameters, cause/effect relationships, and structure provide an explicit "map" of the key similarities and differences among my family of case studies. The recurring similarities define the common ground. They support development of broad, general theories of market behavior. The differences also are highly significant. They indicate factors that must be considered in applying the general theories to new situations. And they suggest how markets may evolve in the future, for example, the factors that would cause a telecommunications market to become much more like air transportation. The model-based approach can facilitate the transfer of strategic insights across markets and products, and thus accelerate learning within a global technology network.

Status of the Research

Three versions of the model are fully developed, calibrated to historical data, and operational. These represent the US air transportation, long-distance telecommunications, and refined petroleum product markets. A fourth version, representing the Hong Kong mobile telecommunications market, is under development.

The three operational models were calibrated to historical data for the period 1985-94. Simulations start in 1985 and run through 2015. The Base Case simulations reproduce quite well the patterns of past behavior of these markets. They use "middle of the road" future scenarios for macro-economic conditions, technological trends, management objectives and policies, and the behavior of customers. With each model the Base Case serves as a reference for analyzing other tests. We have performed a wide range of sensitivity tests with the models, i.e., exploring how the simulation results are affected by changes in various inputs and cause-effect relationships. Recent tests have focused on macro-economic factors, aspects of industry structure, and costs.

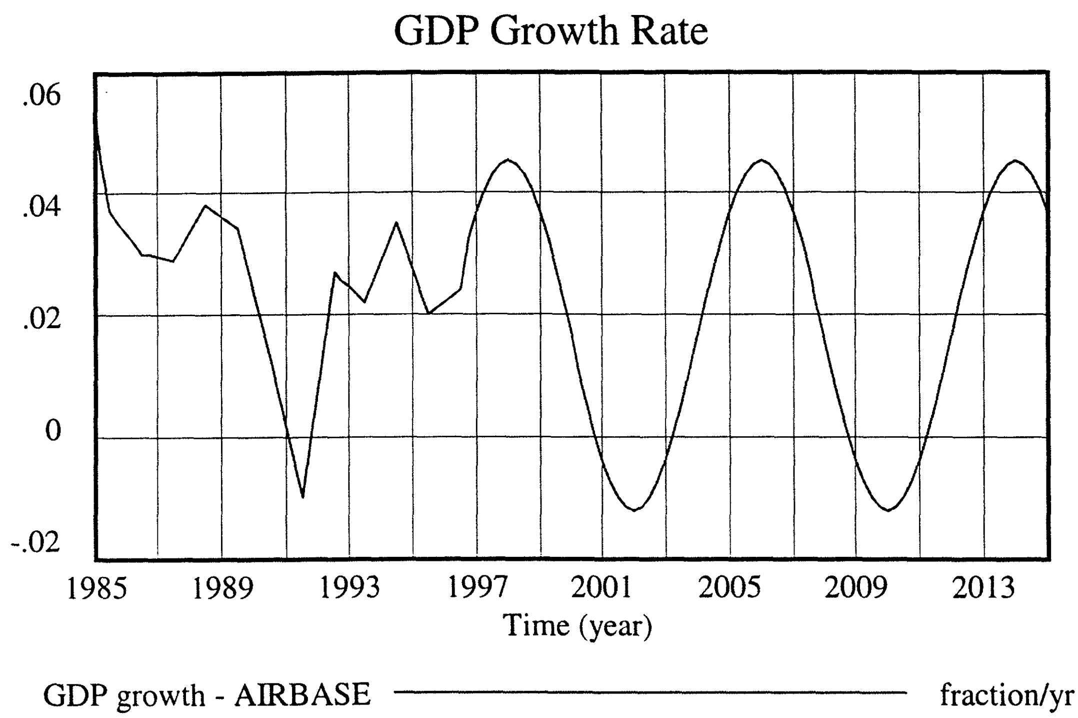
Technical Notes

Financial variables are expressed in current (i.e., ***not*** deflated) US dollars. Graphs of Base Case simulation inputs and outputs for the three versions of the model are labeled AIRBASE (air transportation), TELBASE (telecommunications), and OILBASE (refined petroleum products) respectively.

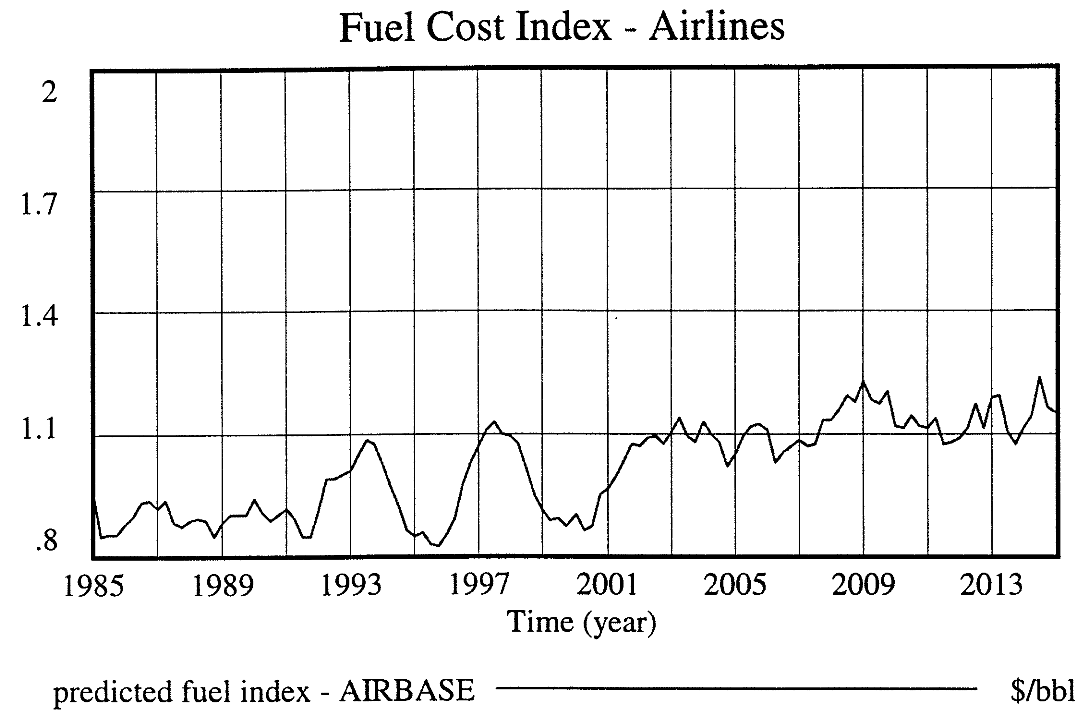
Air Transportation

Base Case Assumptions

All three Base Case simulations share the same scenario for GDP growth. The actual growth rates were used from 1985 through 1996. After 1996 GDP growth is assumed to cycle around an average of 1.7% p.a. (between a maximum of 4.6% and a minimum of -1.2%) with a period of eight years.

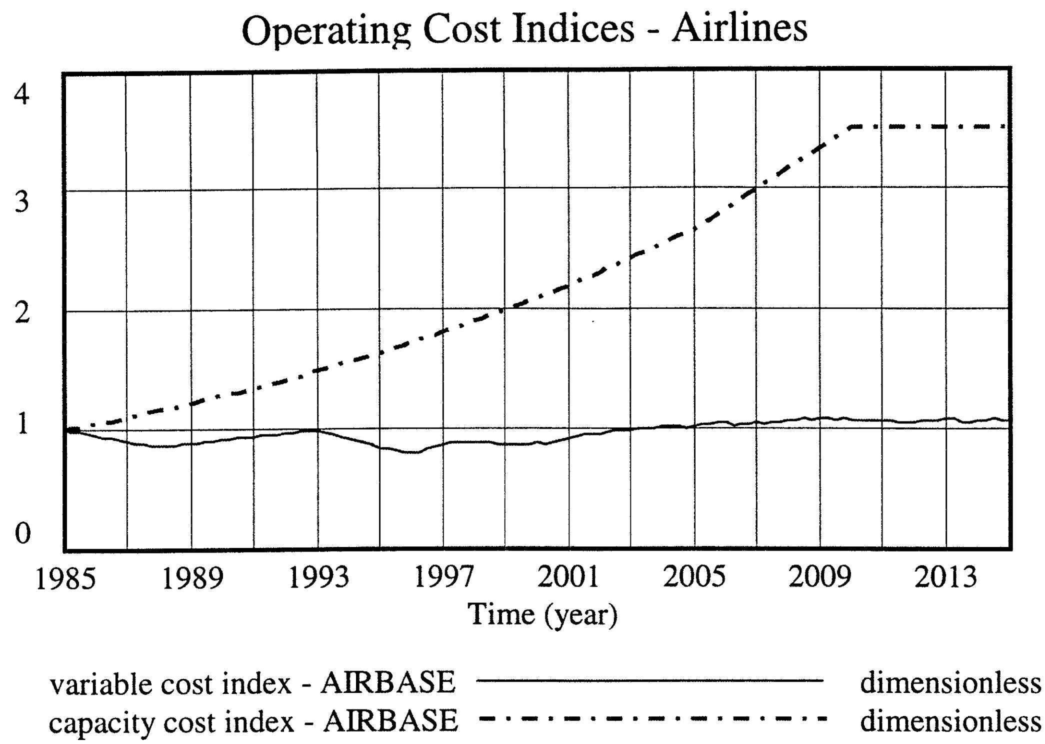


From 1995 onward the price/barrel of aircraft fuel is assumed to rise at an average rate of 1% p.a. Fuel price cycles ±15% around this trend with a period of 6 years. The Base Case fuel price also contains a random element for added realism. Depending on the price level fuel comprises 25-30% of variable operating costs (about 11-16% of total expenses).

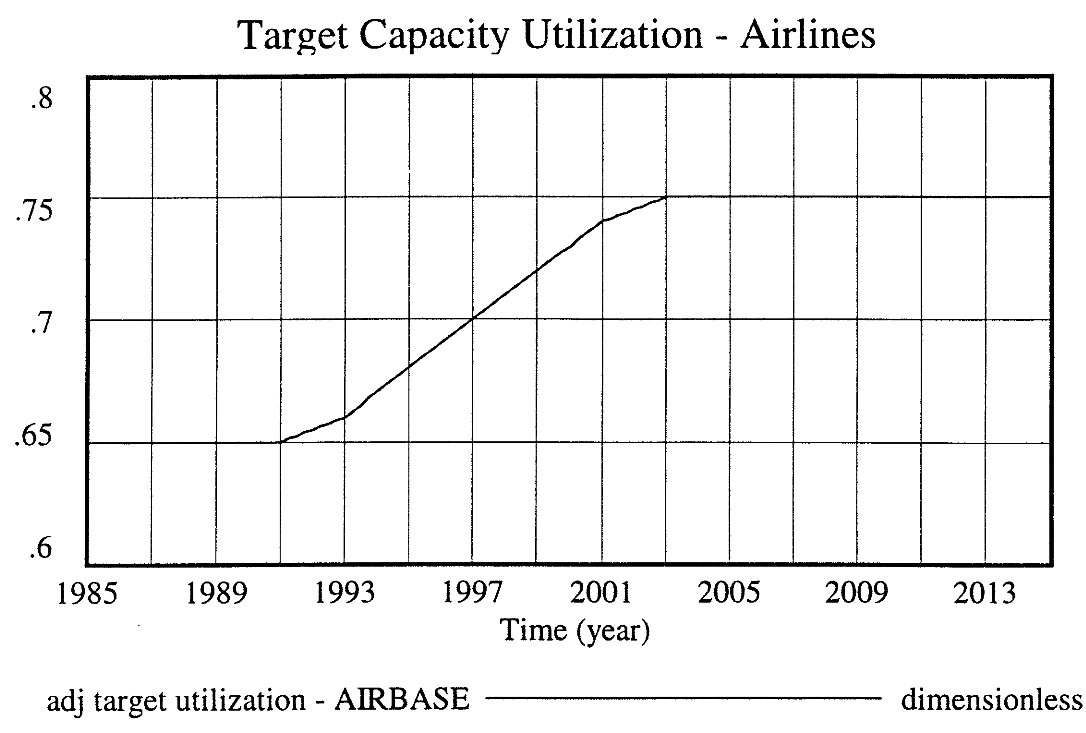


The Base Case cost assumptions differ for each industry. For the airlines it is assumed that capacity-driven cost factors (i.e., the cost/year/unit of capacity) increase at 5% p.a. through 2010. This is a continuation of the historical trend wherein the fixed annual ownership costs of new aircraft (i.e., the financing cost plus depreciation or lease expense per unit of capacity) have escalated quite substantially. After 2010 the cost/year/unit of capacity is constant. The airlines are complaining vociferously about the "unaffordability" of new aircraft, and the Base Case assumes that a new generation of lower cost aircraft enter service.

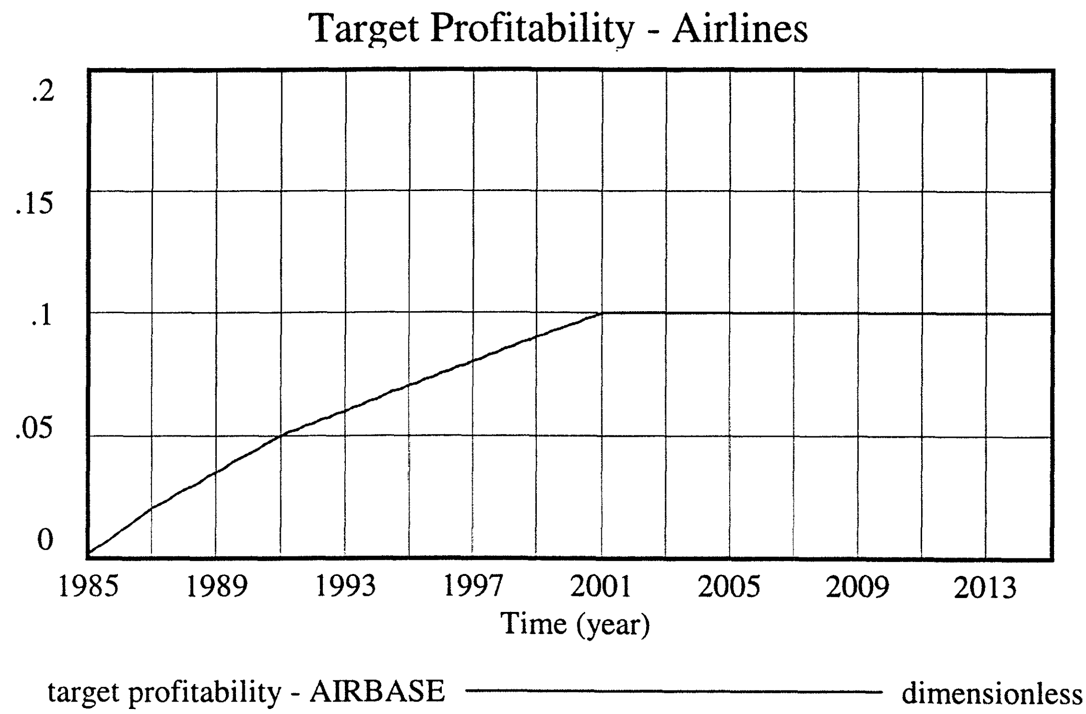
There are two rounds of reduction in variable operating cost factors (i.e., the cost/unit of demand): a 5% p.a. decline during 1985-88 and 8% p.a. in 1993-96. However the recent decline in non-fuel variable operating costs is assumed to be unsustainable. There are limits beyond which restructuring and renegotiating labor contracts "run out of steam," and employees often react to improved margins by demanding catch-up pay increases. In the Base Case non-fuel variable operating cost factors rise by about 3% p.a. over 1997-2005 (i.e., in line with inflation) and 1-2% p.a. thereafter (i.e., another round of real cost reduction).



The airlines' desired capacity utilization is assumed to increase from 65% in 1991 to 75% in 2003.

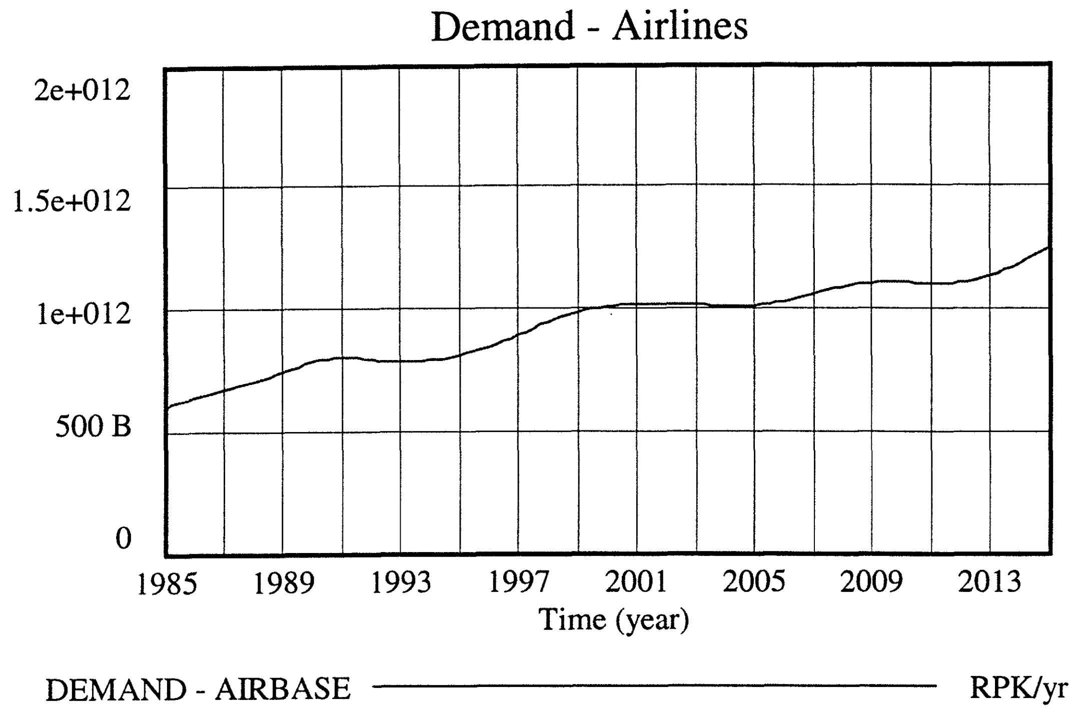


Similarly target profitability (expressed as the ratio of operating profits to revenues) rises to 0.1 in 2001 and stays at that level thereafter. These inputs reflect assumed attempts by the airlines to improve profitability and, later on, the effect of industry consolidation. Please recall that the generic model represents an entire industry. Hence inputs such as target utilization and target profitability reflect the aggregation of many individual companies' decisions.



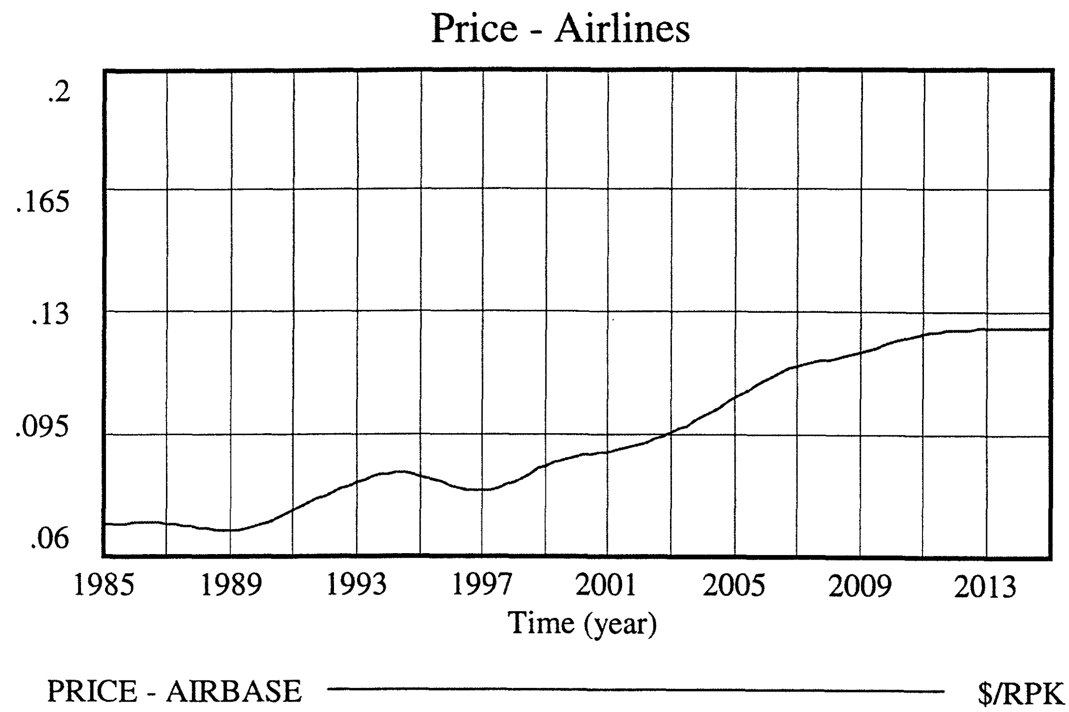
Demand

Demand growth is quite irregular, showing the classic "stair step" pattern. Demand (expressed in revenue passenger kilometers or "RPK"/year) is essentially flat during 1999-2004 and again in 2009-11. The average growth rate slows significantly. It is much higher during 1985-96, i.e., 3.4% p.a., than from 1997 to 2015, i.e., 1.9% p.a. Demand growth surges in 1994, driven by strong economic growth and in addition the market's reaction to declining fares during 1995-96. Then demand growth peaks in 1997 and cycles sharply downward. This reversal is caused by rising fares and the assumed economic down-cycle. As described above a recession is assumed in 2001-02.



Price

From 1997 onward fares (in nominal, inflated terms) trend consistently up, following a more moderate version of the stair step pattern exhibited by demand. Between 1997-2010 fares rise at an average of 3.4% p.a. Cycles in capacity utilization cause the irregular pattern of price movements. The upward trend reflects a long-term increase in the airlines' unit cost and also rising target profitability. Between 1989-99 the airlines' pricing is assumed to become substantially more sensitive to capacity utilization because of an inflow of new entrants and an aggressive response by incumbents. The sensitivity of pricing to utilization declines after 2005, reflecting an assumed shake-out and consolidation in the industry. Lower than desired utilization depresses fares by 7% during 1995-96 and 5% in 1997. This effect becomes significant again between 2002-06, depressing fares by as much as 9% in 2004.



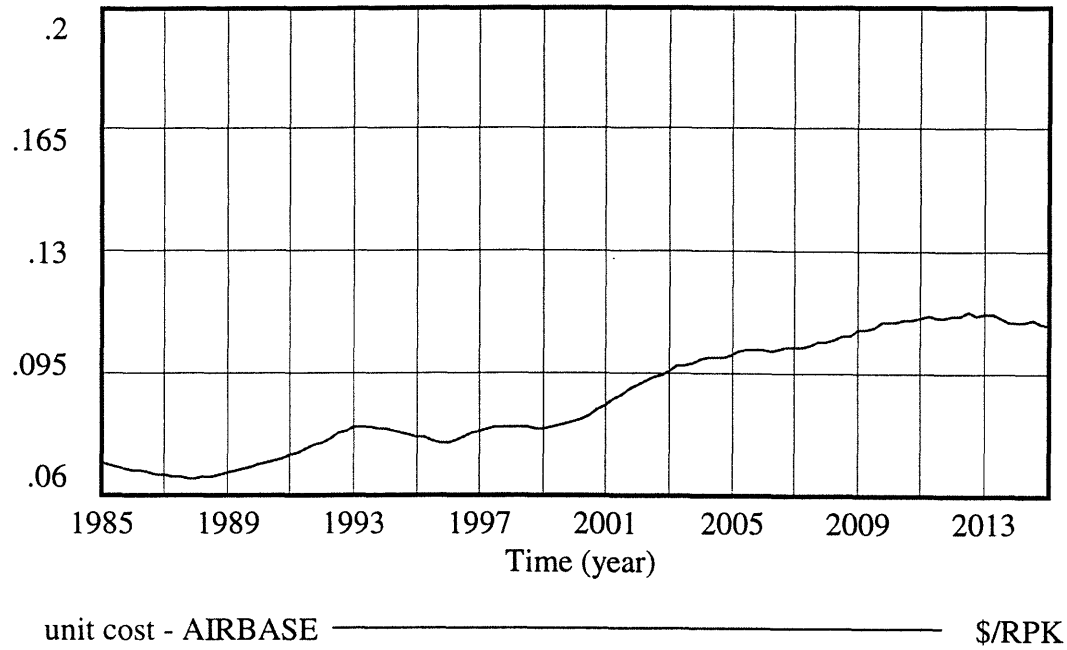
Costs

After the two rounds of cost reduction in 1985-88 and 1993-96 the airlines' unit cost, i.e., operating expense/RPK (in nominal, inflated terms), rises steadily from 1997 through 2013. The average rate of increase over that period is 2.3% p.a.

The reductions in variable operating costs are, in part, the assumed responses to periods of poor profitability. The down-cycle in the cost of fuel during 1994-96 is a fortuitous benefit. The fuel price moves upward in 1997 and cycles, with a trough in 2000. Between 2000-10 the price of fuel increases by about 20%. As described above the reduction in non-fuel variable operating costs is assumed to be unsustainable. These cost factors rise by about 3% p.a. 1997-2005 (i.e., in line with inflation) and 1-2% p.a. thereafter. The airlines' fixed operating costs rise steadily from $33 b. in 1997 to $65 b. in 2010 (an average increase of about 5.4% p.a.). Capacity-driven costs rise from 47% of total expenses to 54% over that period.

Costs	1997	2000	2005	2010
variable	37 b	42 b	49 b	56 b
fixed	33 b	40 b	52 b	65 b
total	70 b	82 b.	101 b	121 b
% fixed	47%	49%	51%	54%
% fuel	16.3%	13.0%	12.5%	12.1%

Unit Cost - Airlines



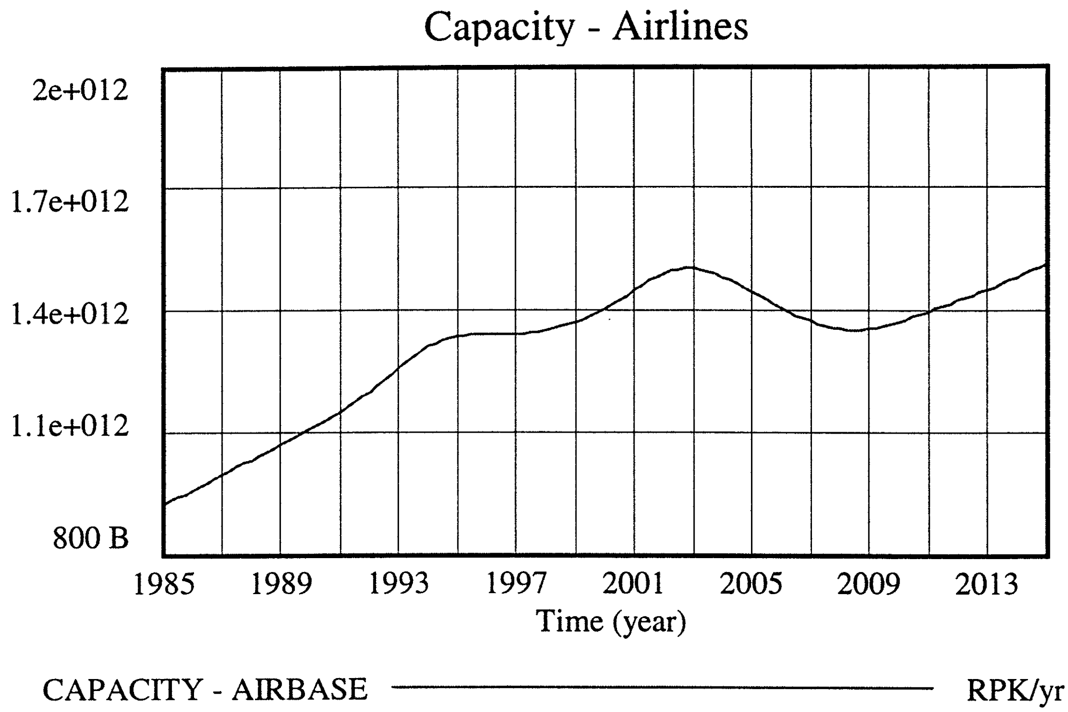
Capacity

After a surge in the mid-1980s through the early 1990s capacity growth slows substantially in 1995-97. Growth picks up for several years starting in 1998, but then it stops quite suddenly in 2001. Capacity actually shrinks between 2002-08.

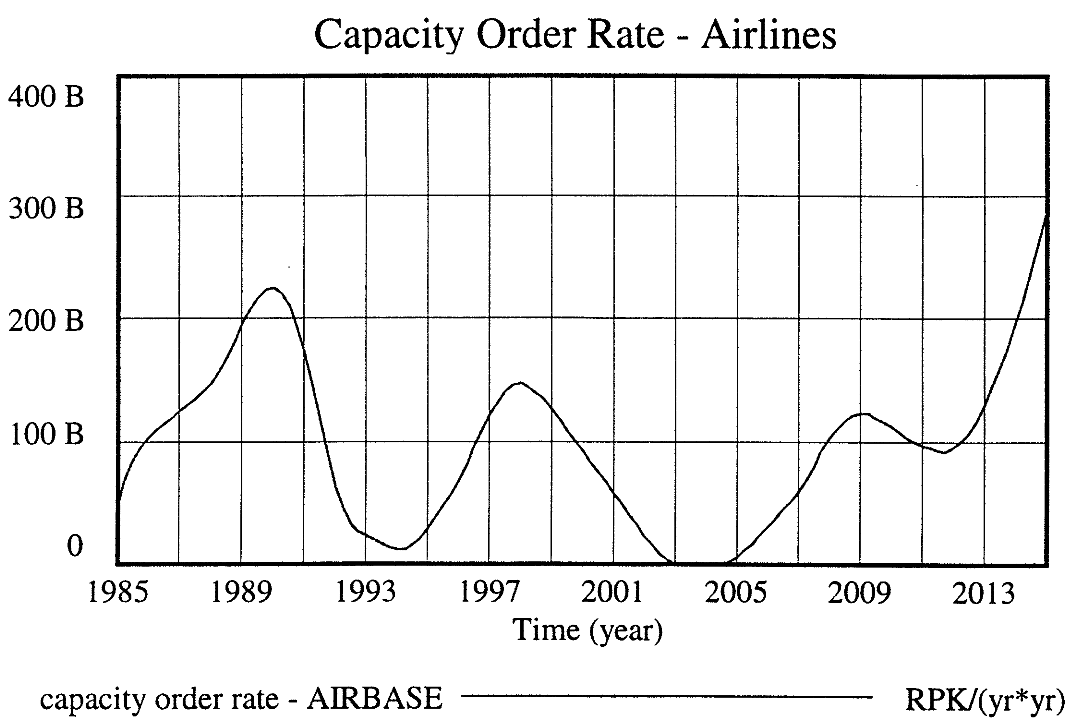
Capacity orders go through very severe cycles with peaks in 1990, 1998, and 2009. Orders decline steadily after 2008 and are zero during 2003-04. They recover slowly starting in 2005. By 2009 capacity orders reach almost 85% of the previous peak. The down-cycle during 1999-2004 is even more extreme than the one in 1992-95. These down-cycles are caused by the combination of low capacity utilization and poor profitability. Both effects are substantially stronger in 1999-2004 than in the earlier cycle (particularly the profit effect). Low utilization also causes pressures for accelerated capacity retirements.

In the generic model the profit and utilization effects on capacity orders and pricing act as multipliers. A value below 1.0 scales back what otherwise would be the decision outcome, e.g., lower capacity orders than forecasted demand and fleet replacement would dictate.

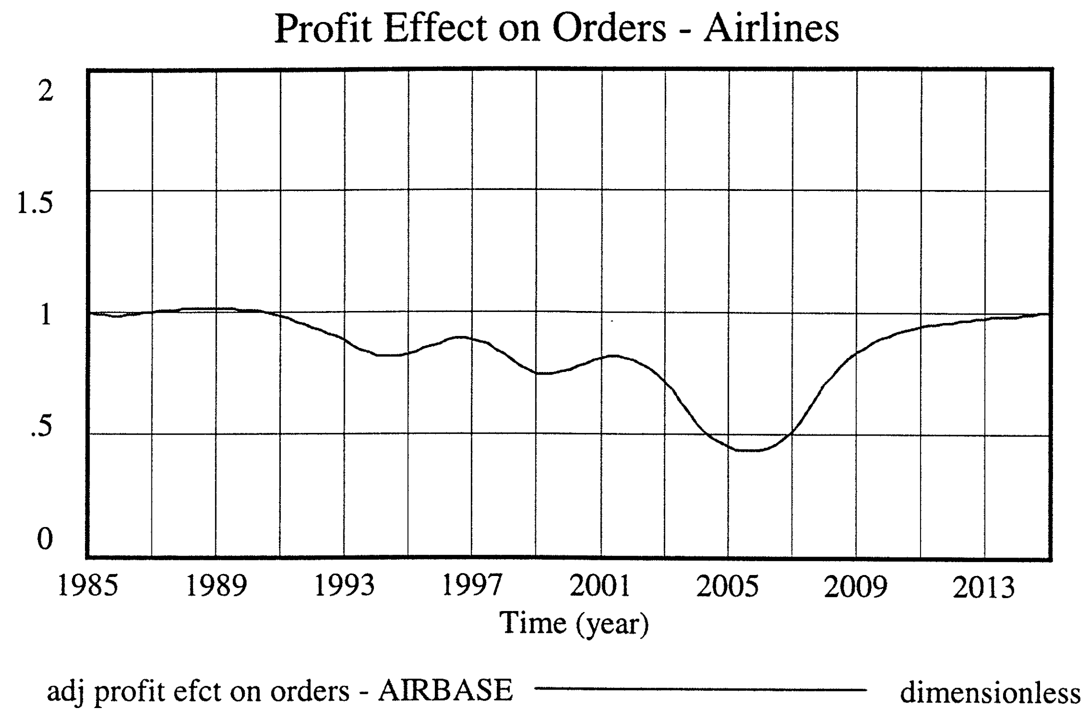
Increased aircraft production rates keep the order cycle from being worse than otherwise. The delivery time becomes longer than normal (i.e., 5 years *vs.* 3 years) but does not reach the extreme (i.e., 7 years) of the previous cycle.



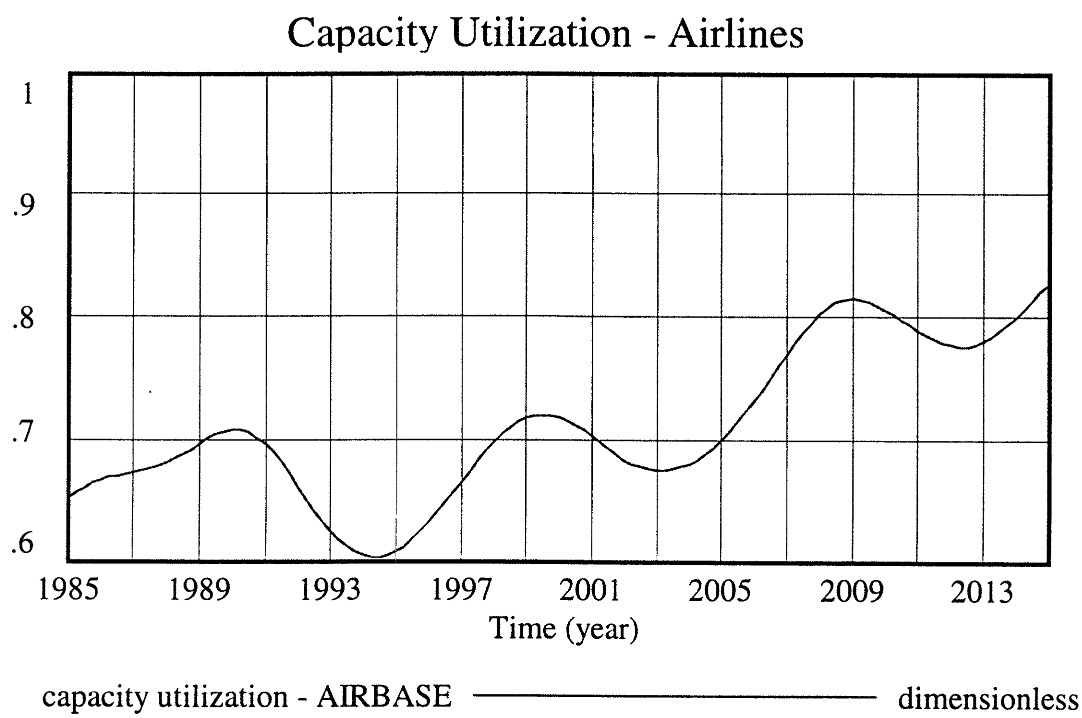
Capacity - Airlines
2e+012
1.7e+012
1.4e+012
1.1e+012
800 B
1985
1989
1993
1997
2001
2005
2009
2013
Time (year)
CAPACITY - AIRBASE
RPK/yr



Capacity Order Rate - Airlines
400 B
300 B
200 B
100 B
0
1985
1989
1993
1997
2001
2005
2009
2013
Time (year)
capacity order rate - AIRBASE
RPK/(yr*yr)



Profit Effect on Orders - Airlines
2
1.5
1
.5
0
1985
1989
1993
1997
2001
2005
2009
2013
Time (year)
adj profit efct on orders - AIRBASE
dimensionless

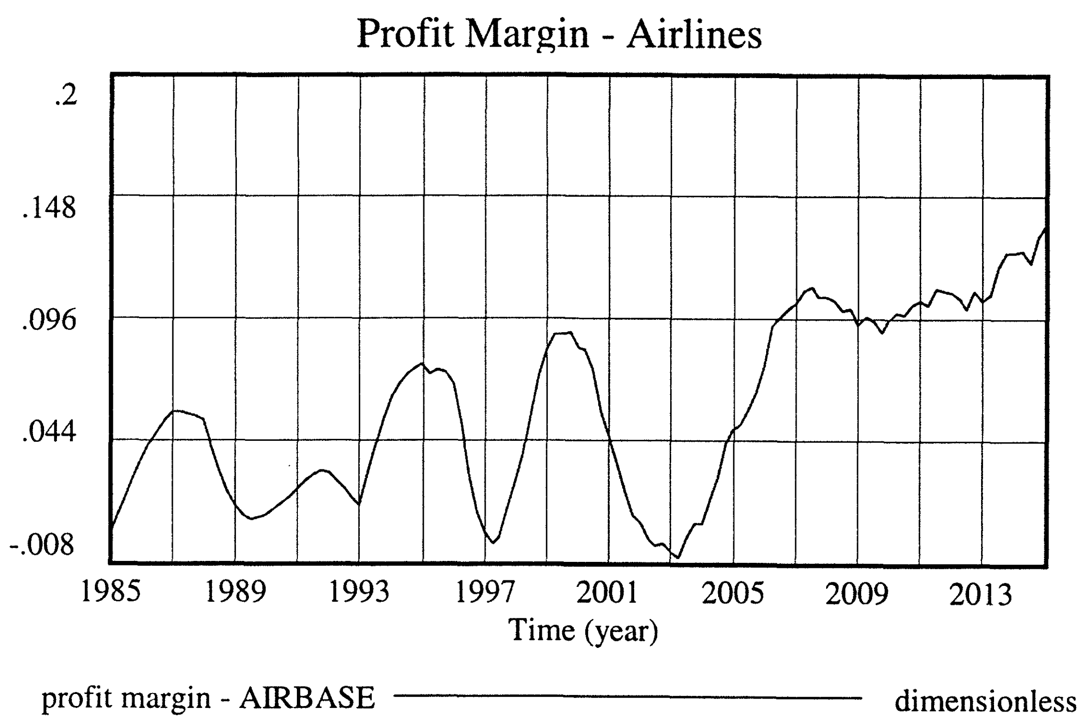


Capacity Utilization - Airlines
1
.9
.8
.7
.6
1985
1989
1993
1997
2001
2005
2009
2013
Time (year)
capacity utilization - AIRBASE
dimensionless

Profitability

Profit margin (i.e., operating profits/revenues) rises strongly from its trough of 1-2% to 7-8% in 1994-95, before cycling downward in 1996. Margins begin to recover in 1997 and then plunge to -1% in 2002-03. This is a worse crisis than the early 1990s! Between 2007-15 margins are significantly higher and more stable, averaging almost 11%.

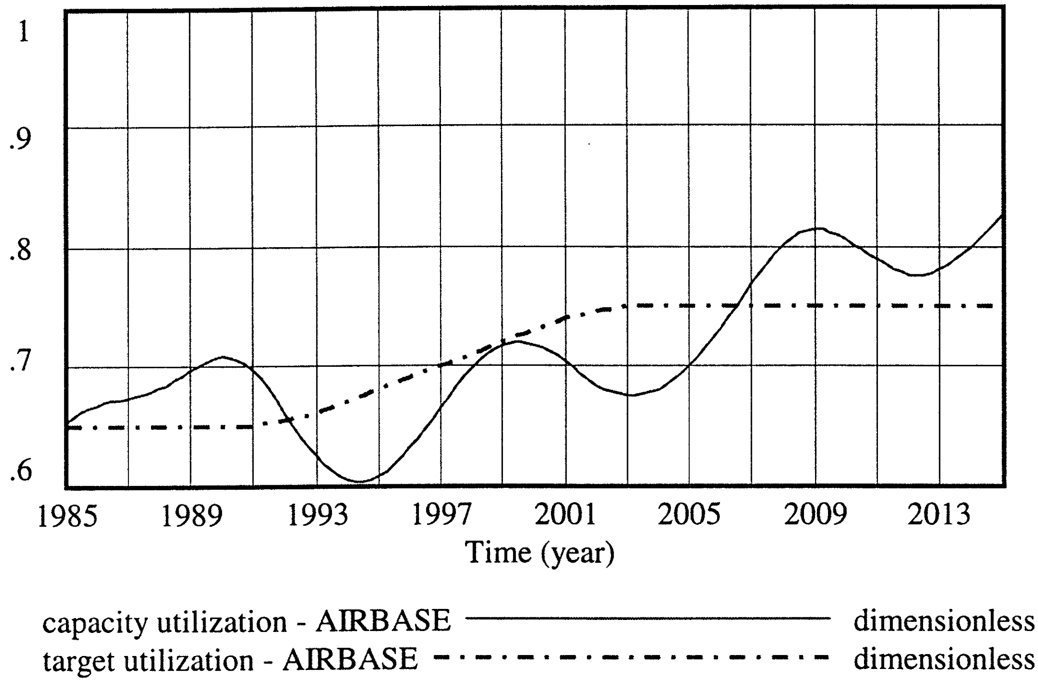
Not surprisingly margins are satisfactory in periods where revenues are growing faster than expenses. The two rounds of variable cost reduction (1985-88 and 1993-96) temporarily boost margins, but they are followed by periods of cost growth, weak demand, and stagnant revenues. Revenue growth is quite weak during 1999-2003. This results from flat demand (caused by fare increases in 1997-98 plus the assumed recession) combined with substantial pressures on price from low capacity utilization. A very modest rise in fares partially off-sets the impact of flat demand. As demand strengthens and utilization improves in 2004, fares are raised more aggressively and margin recovers dramatically. Starting in 2010 the assumed lack of further growth in the average cost/year/unit of capacity significantly boosts margins.



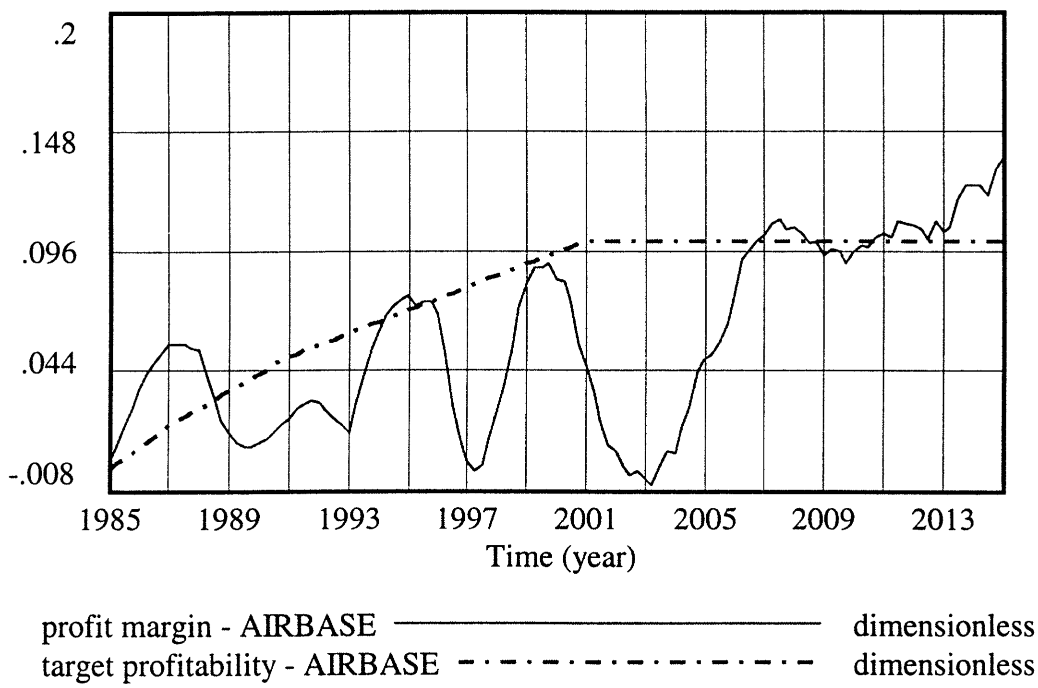
Performance

From the early 1990s until 2006 capacity utilization lags behind rising industry targets. Profitability also generally falls short of targets, except during periods of cost reduction and exceptionally high capacity utilization. Only after utilization exceeds 75% does operating margin stabilize in the 10-12% range. As explained above margin growth after 2010 is caused by the assumed leveling off of capacity driven cost factors.

Utilization *vs.* Target - Airlines



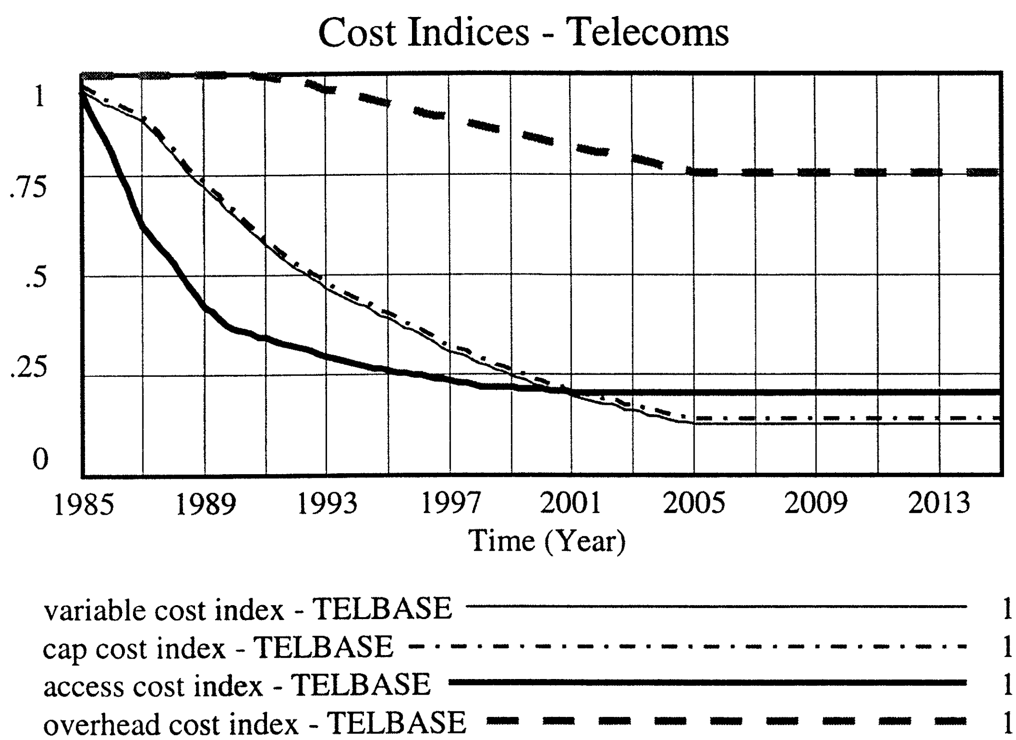
Profits *vs.* Target - Airlines



Long Distance Telecommunications

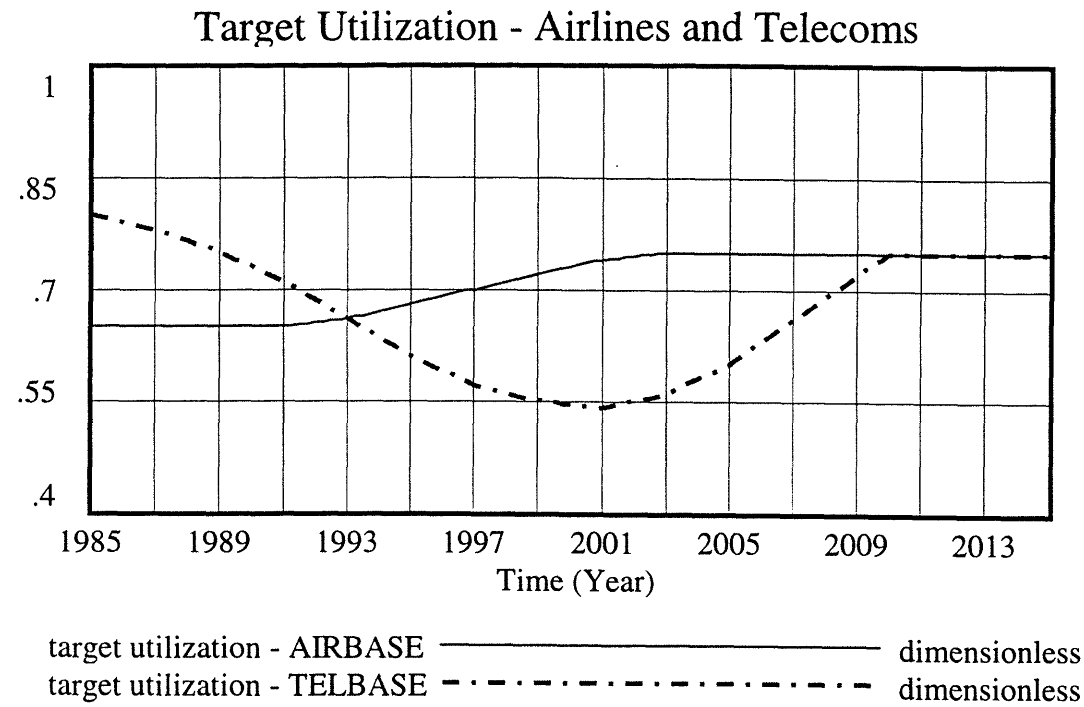
Base Case Assumptions

Long distance telephony is an information technology-intensive business. Thus it is assumed that, in approximate terms, "Moore's Law" applies and new technology will drive costs downward. Specifically both capacity and variable cost factors are assumed to decline by 10% p.a. over 1985-2005 and remain constant thereafter. This assumption was based on analysis of AT&T's historical cost trends from 1984-94. In the Base Case the telecoms' overhead cost factors decline by 2% p.a. between 1990 and 2005. This input reflects attempts to improve profitability and the effect of industry consolidation.



For long-distance operators "local access" costs (i.e., the payments to local telephone operators for originating and delivering long distance calls) are very significant. The historical trend from 1984-94 for local access cost factors was extrapolated into the future. These cost factors decline at an average rate of 9.6% p.a. over 1985-2002, reflecting cost reductions and, later on, greater competition in local services. After 2005 all costs are assumed to remain constant in nominal terms (i.e., real costs decline at the rate of inflation).

Unlike with the airlines (where target utilization increases over time) the telecoms' target utilization is assumed to decline from 78% in 1985 to 54% in 2001, and then rise to 75% in 2010 and beyond. This reflects mid-term assumptions regarding: (a) liberalization of the market; (b) entry of a number of infrastructure-based competitors (each with their own network capacity), e.g., the RBOCs, Worldcom, the cable companies; and (c) aggressive expansion by foreign telecoms, e.g., BT. In the longer-term it reflects the effects of industry consolidation and attempts by the telecoms to improve profitability.



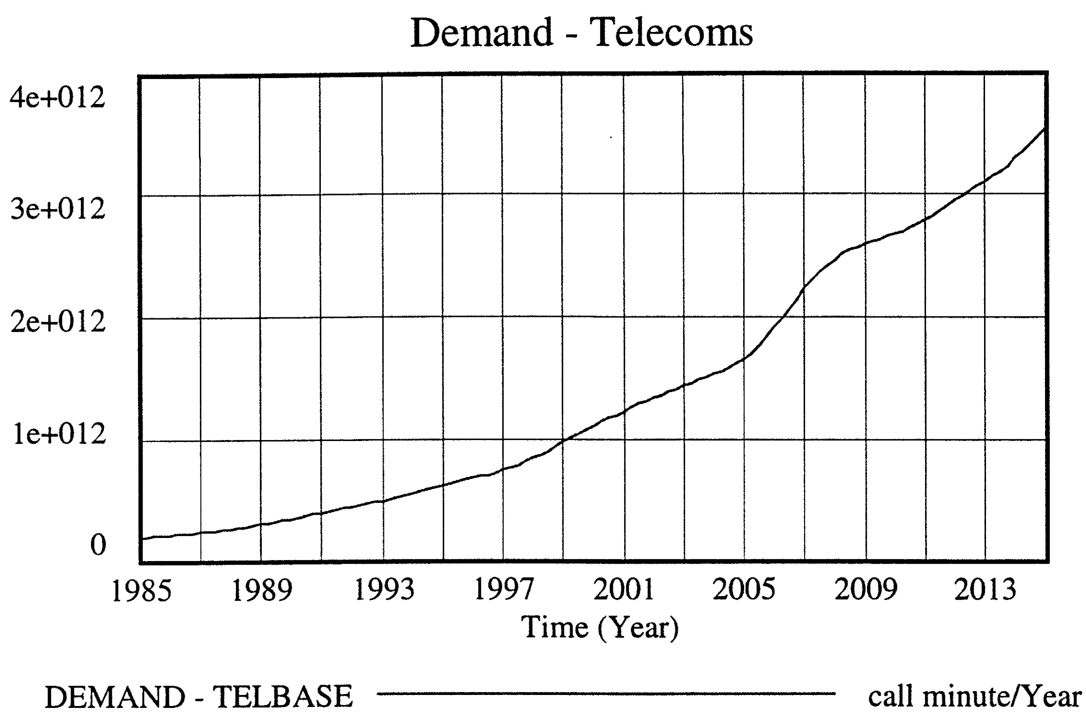
The telecoms' target profitability (expressed as the ratio of operating profits to revenues) is assumed to be constant over time at 0.3. This is substantially higher than the airlines' long-term target margin of 0.1. It is consistent with the Base Case assumptions about costs, i.e., that the telecoms will not expect declining prices to erode their margins because costs will fall at least as fast.

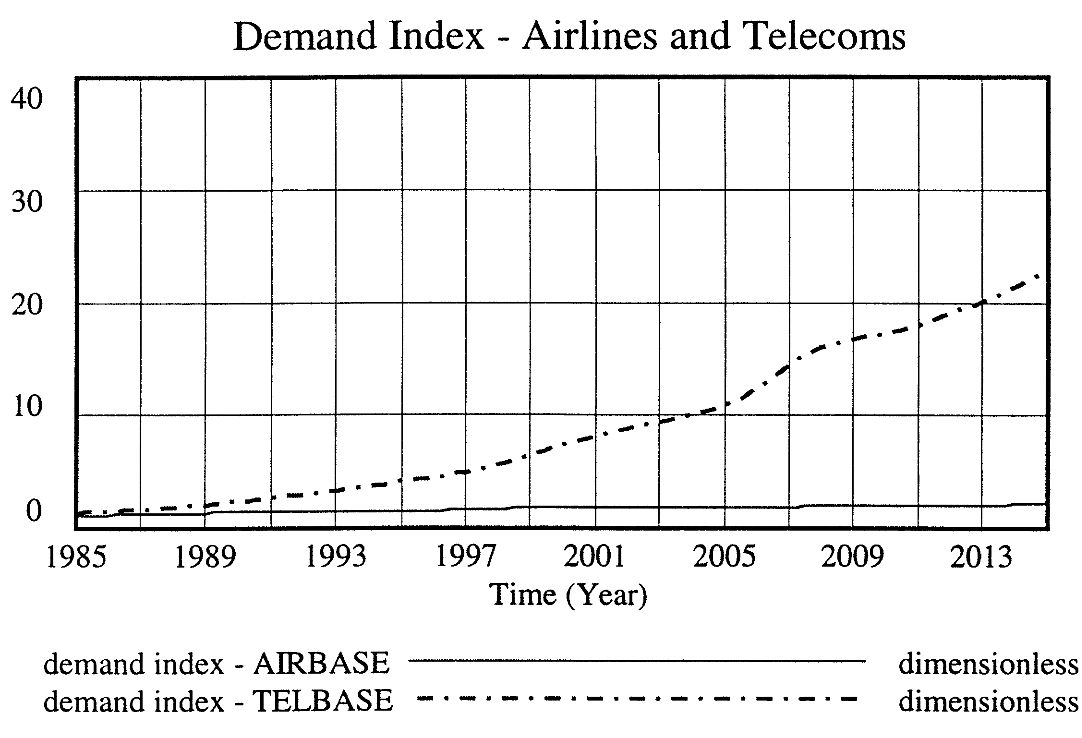
<u>Demand</u>

Demand growth becomes increasingly irregular, showing the classic "stair step" pattern after 2001. Over the simulated thirty-year period demand (expressed in call-minutes/year) grows at an average rate of 10.3% p.a. As with the airlines the average growth rate slows significantly. Demand growth during 1985-96 is much higher, i.e., 12.2% p.a., than in 1997-2015, i.e., 9.1%.

Between 1985-2005 demand growth is being driven primarily by declining prices. Demand accelerates in 1996 because of strong economic conditions. The growth rate peaks in 1999 and cycles sharply downward. This reversal is caused by the assumed economic down-cycle (a recession occurs in 2001-02) and a somewhat slower decline in prices. Demand recovers very strongly with the economy, exceeding 16% p.a. growth in 2006. The surge in demand is amplified by an acceleration in price-cutting caused by unsatisfactory capacity utilization.

Then demand growth collapses. It drops to 3% p.a. in 2009 before bouncing back to an average of about 6% 2011-15. Another recession is assumed in 2009. This follows a major shift in the telecoms' pricing. The rate of price reduction slows to zero between 2006-07, and prices actually rise somewhat starting in 2012.

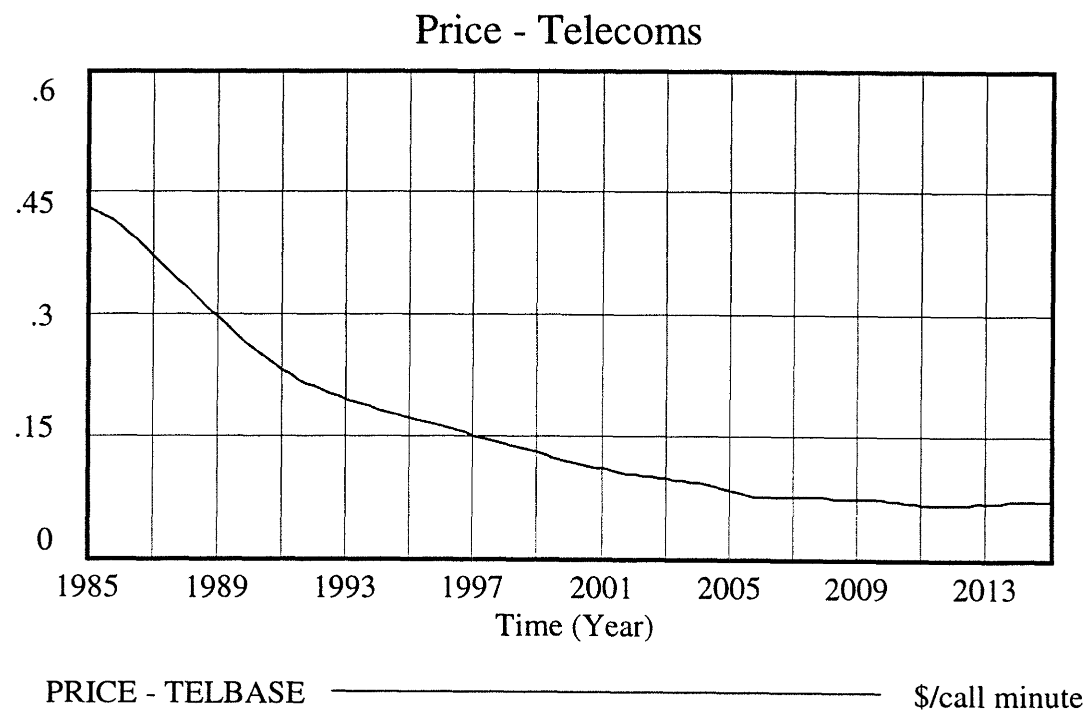




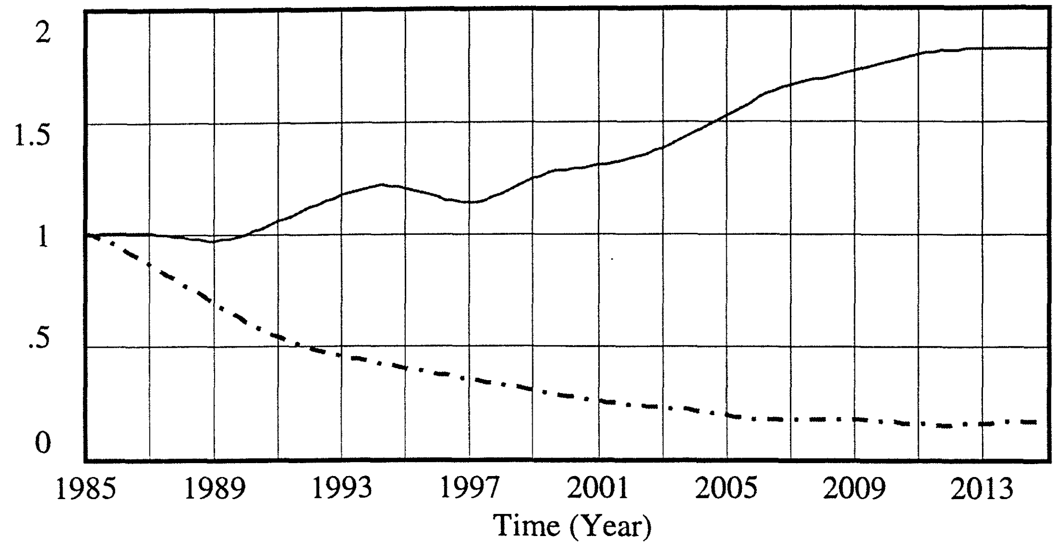
Price

Price per call-minute drops dramatically between 1985 and 2005, i.e., to 20% of its initial value. The average rate of price reduction over that period is 8.6% p.a. Price follows a far more moderate version of the irregular stair step pattern visible in demand. It is essentially flat from 2006 onward.

Prices are driven primarily by declining unit cost. Utilization generally is not a factor here, unlike with the airlines. Recall that the telecoms' target utilization is assumed to decline from 78% in 1985 to 54% in 2001, and then rise to 75%. While highly cyclical, utilization is above target until 2003. In 2005 and again in 2011 unsatisfactory utilization has a significant downward effect on price. In the absence of utilization pressures on price profitability remains quite satisfactory until after 2005, and its effect on prices is negligible. Please recall that the loading effect on price acts as a multiplier. A value less that 1.0 reduces price below what otherwise would be dictated by unit cost and the effects of profitability and capabilities.

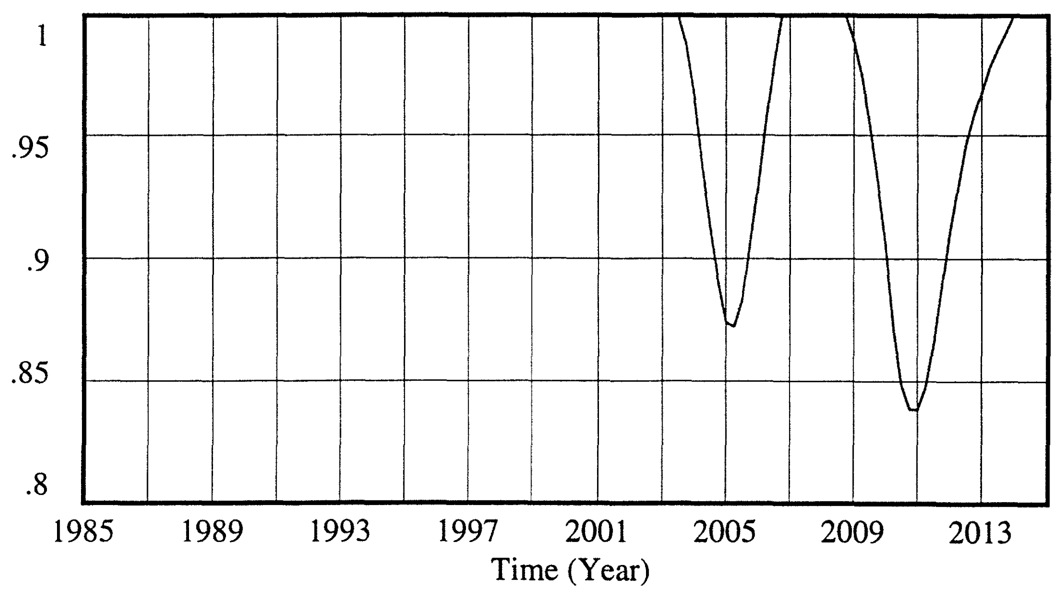


Price Index - Airlines and Telecoms



price index - AIRBASE ——— dimensionless
price index - TELBASE -·-·-·- dimensionless

Loading Effect on Price - Telecoms



adj loading efct on price - TELBASE ——— 1

Costs

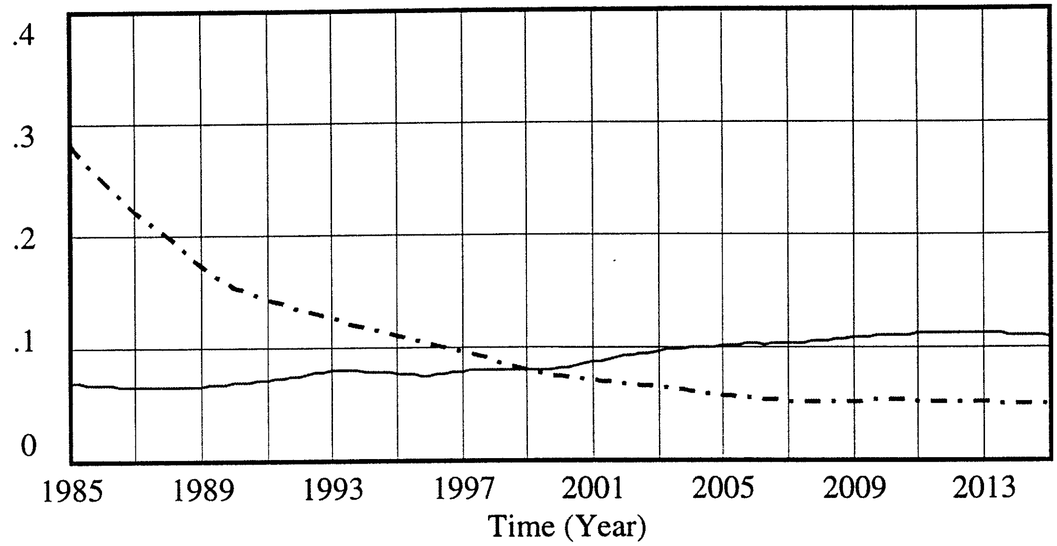
The telecoms' unit cost, i.e., operating expense/call-minute (in nominal, inflated terms), declines steadily from 1986 to 2005. The average rate of decrease over that period is 8.4% p.a.. After 2006 unit cost levels off and then rises very slightly.

Recall that both capacity-driven and variable cost factors are assumed to decline by 10% p.a. over 1985-2005 and remain constant thereafter. Local access cost factors decline at an average rate of 9.6% p.a. over 1985-2002. And after 2005 all costs are assumed to remain constant in nominal terms (i.e., real costs decline at the rate of inflation). The telecoms' variable operating costs rise steadily from $30 b. in 1997 to $82 b. in 2010 (avg. increase of about 8% p.a.). Capacity-driven costs decline from 58% of total expenses to 41% over that period. One can see from the table below that access costs become a far larger fraction of the long-distance telecoms' total operating expenses.

Costs	**1997**	**2000**	**2005**	**2010**
variable	30 b	38 b	50 b	82 b
fixed	41 b	43 b	43 b	57 b
total	71 b	81 b.	93 b	139 b
% fixed	58%	53%	46%	41%
% access	32%	39%	50%	52%

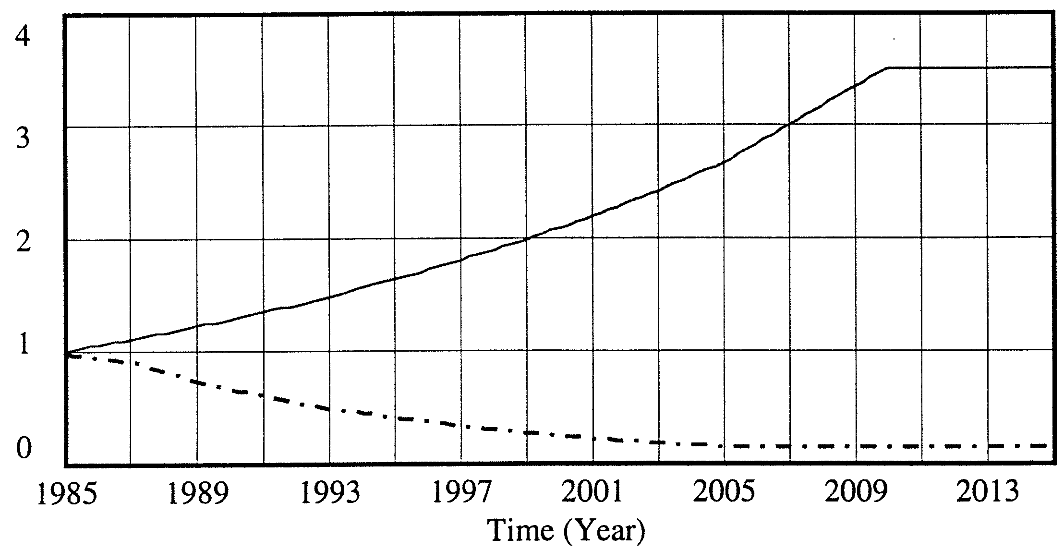
All of this is dramatically different from the airlines, where technology pushes capacity costs steeply upwards and variable cost factors are approximately constant except during times of aggressive (and unsustainable) cost cutting and restructuring. Thus the airlines fraction of fixed costs rises from 47% to 54%, i.e., an increased domination by fixed capacity-driven costs, while the opposite trend occurs with the telecoms. Local access costs become an ever greater burden on the long-distance telecoms as technology drives down the other cost factors. Other variable costs decline substantially more than access costs, while fixed capacity-driven costs decrease as a fraction of the total.

Unit Cost - Airlines and Telecoms



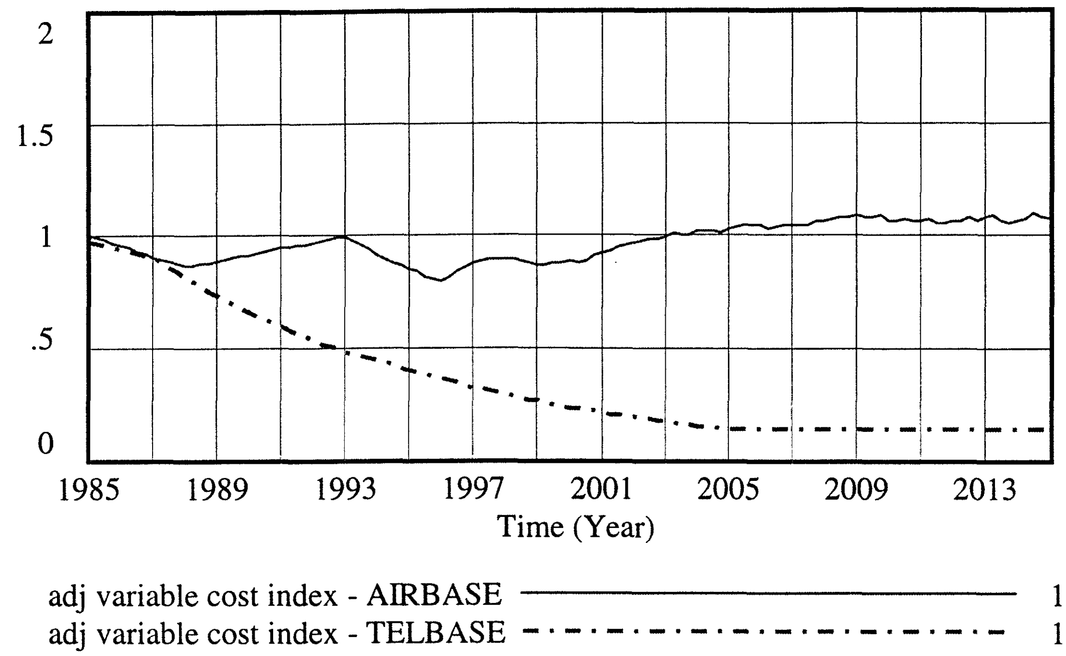
unit cost - AIRBASE ———————— $/RPK
unit cost - TELBASE - · - · - · - · - $/call minute

Capacity Cost Index - Airlines and Telecoms

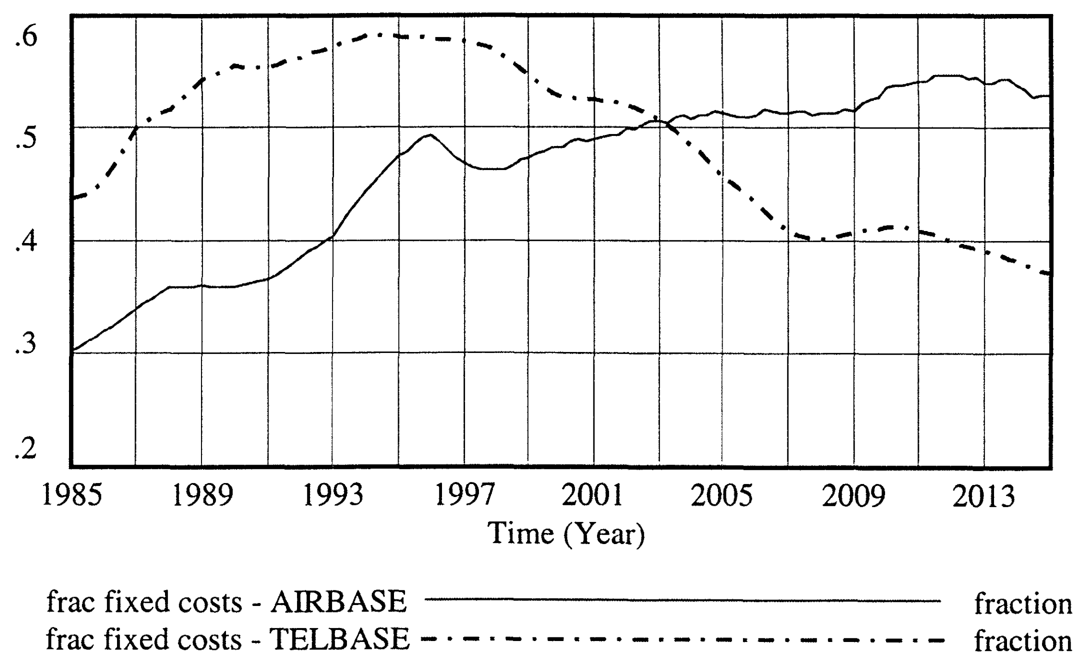


adj capacity cost index - AIRBASE ———————— 1
adj capacity cost index - TELBASE - · - · - · - · - 1

Variable Cost Index - Airlines and Telecoms

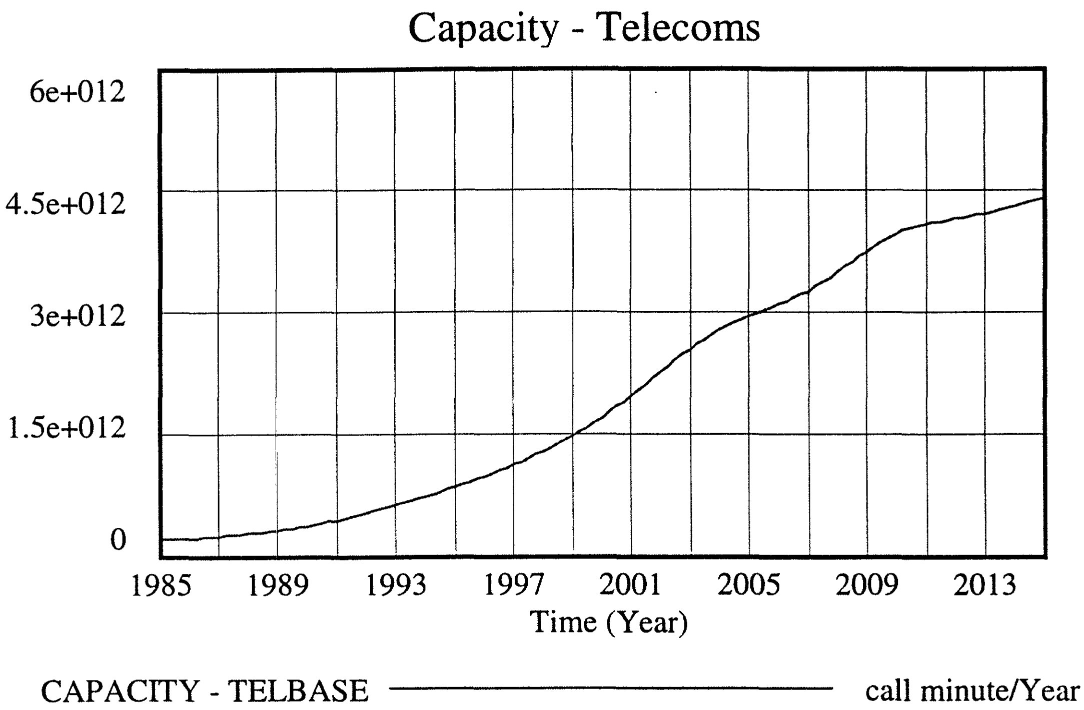


Fraction Fixed Cost - Airlines and Telecoms



Capacity

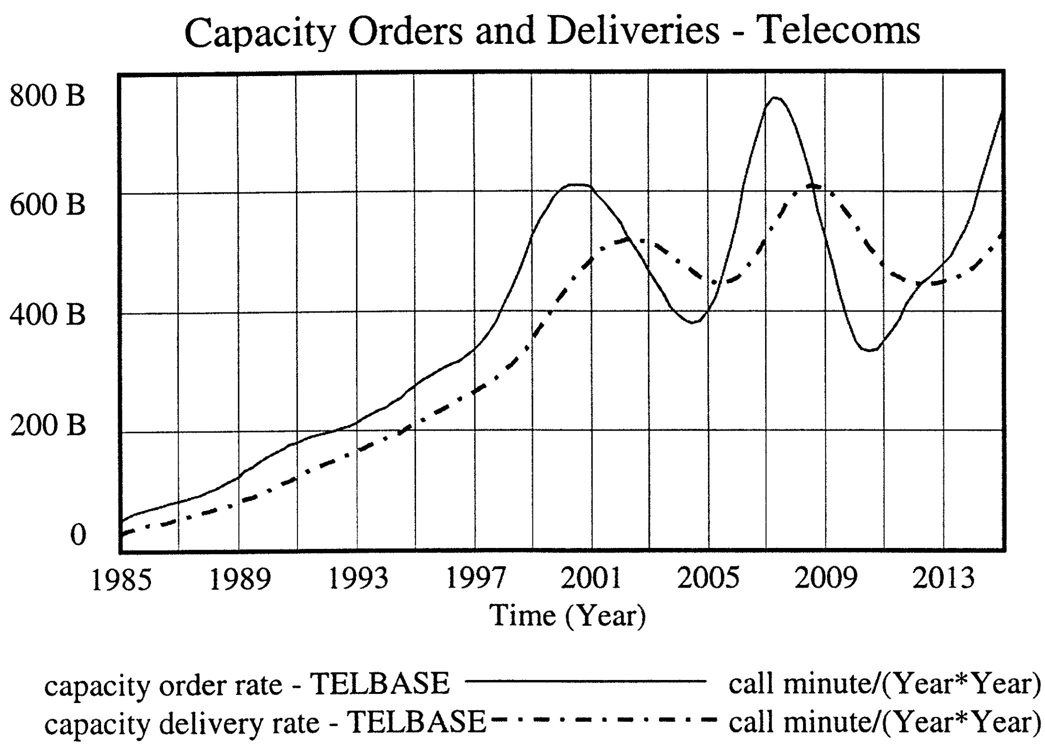
Capacity grows steadily from 1985 through 2009 at an average rate of 13% p.a., but then the growth rate decelerates. From 2004 onwards a very moderate version of the stair step pattern becomes visible.

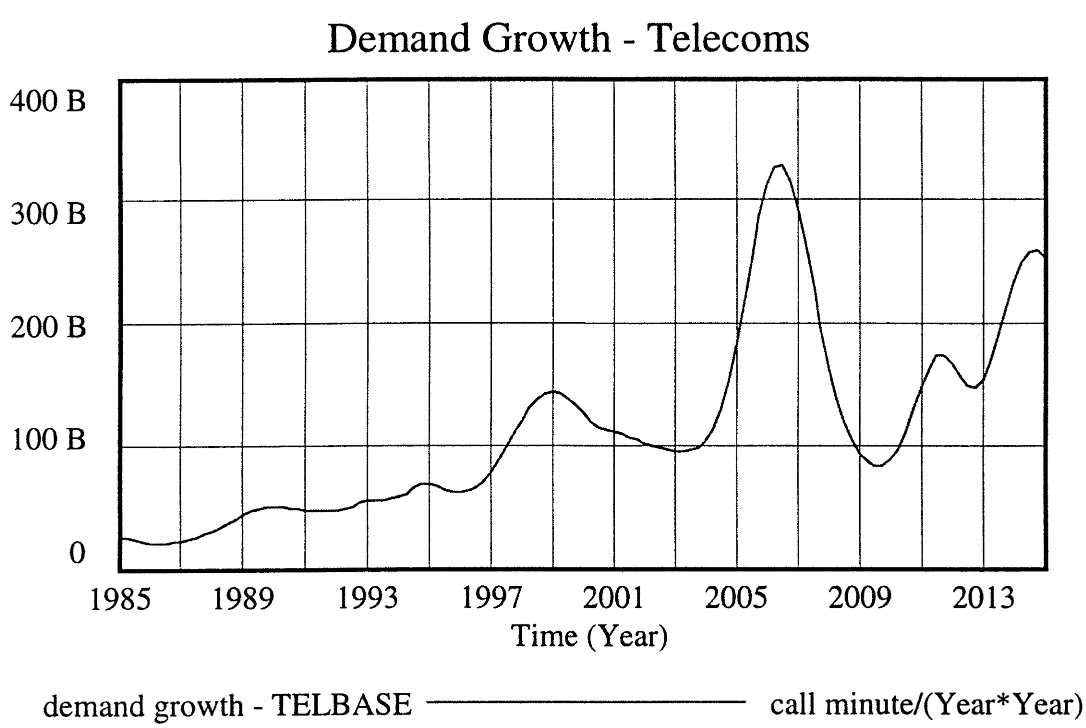


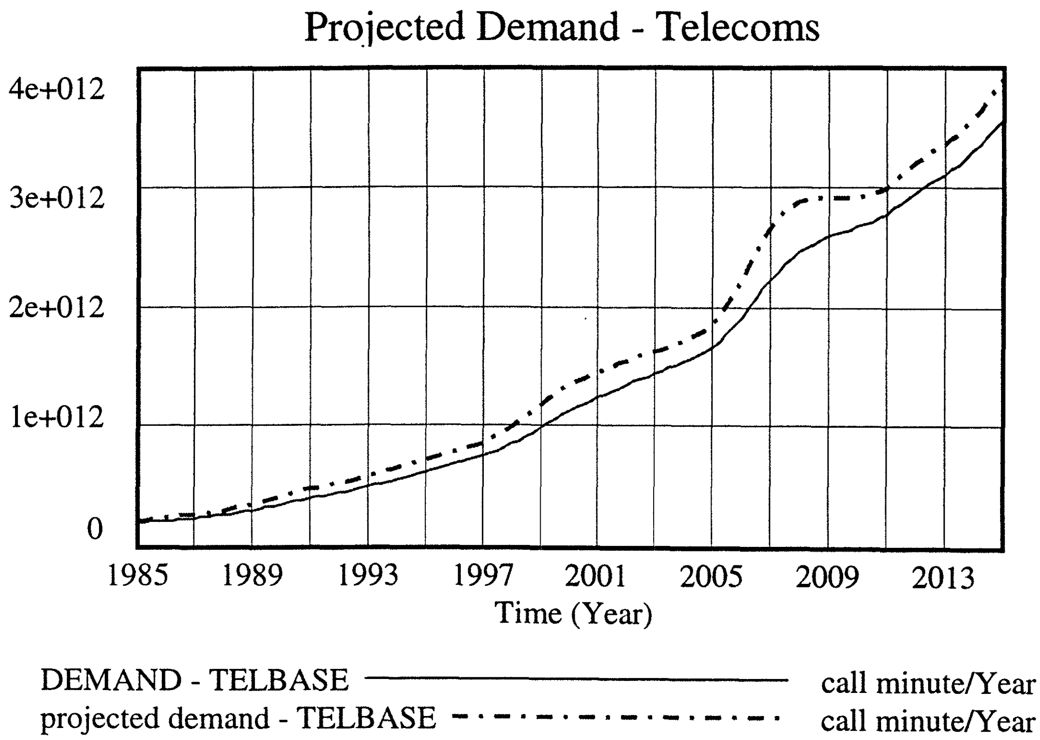
The pattern of telecom capacity orders becomes increasingly volatile over time. Having grown smoothly from 1985 to 1996, capacity orders surge between 1997-99 and then cycle dramatically downward. Orders surge again between 2004 and 2007 and then cycle downward even more sharply. The trough in 2010 is about 45% of the peak in orders three years earlier. Capacity orders then recover and by 2015 almost reach the previous peak.

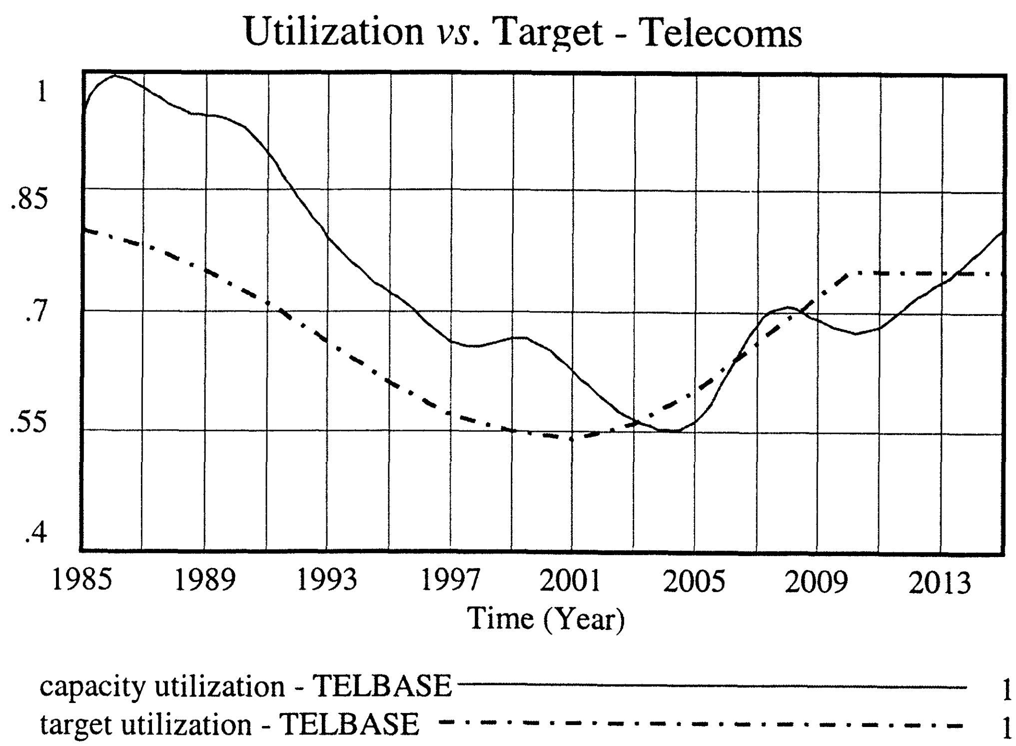
The first big cycle in orders results from an overreaction to rapid demand growth during 1997-99. When the economy slows and demand growth decelerates to less than half its previous peak (i.e., from about 15% p.a. down to 6.5%) the telecoms cut back their capacity orders in response.

The subsequent cycles are amplified by a fundamental shift in the performance orientation of the telecoms. Until 2003 they add capacity in response to projected demand and their very relaxed capacity utilization targets. The surge in demand growth between 2004-06 stimulates another over-reaction in capacity ordering. After a delay a large inflow of new capacity results. When demand growth slows the telecoms for the first time perceive themselves as having significant excess capacity. The combination of rising target utilization and quite low projected demand growth causes a substantial reassessment of desired capacity and hence capacity orders. Starting in 2012 orders also are scaled back because of profitability pressures.

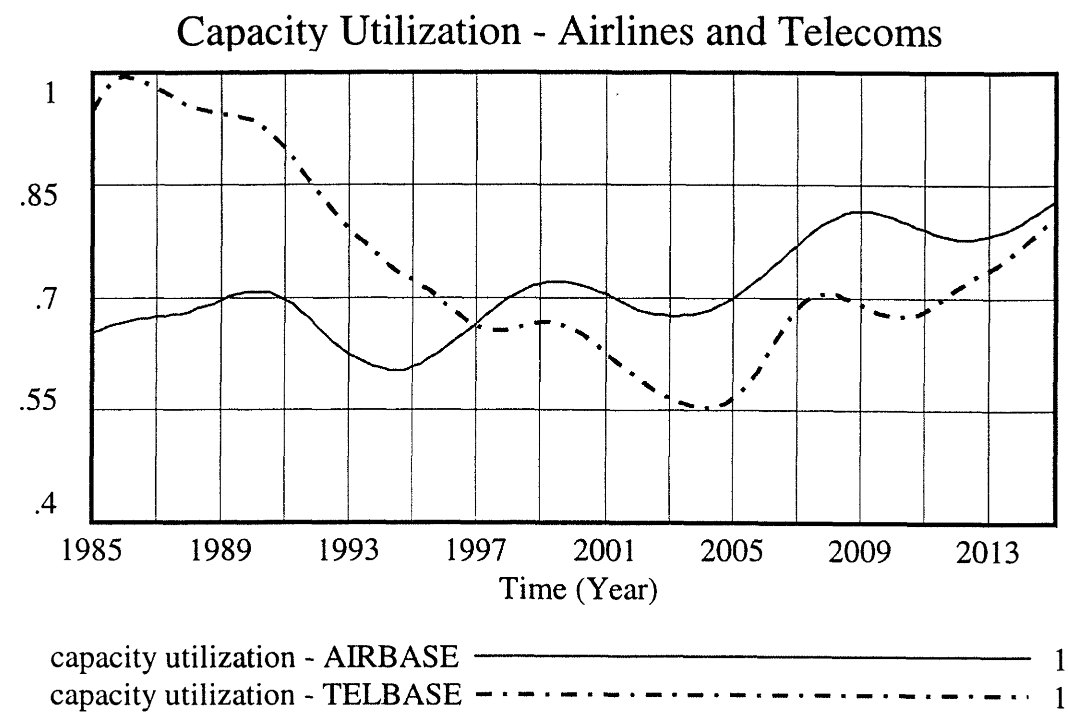





Projected Demand - Telecoms
4e+012
3e+012
2e+012
1e+012
0
1985 1989 1993 1997 2001 2005 2009 2013
Time (Year)
DEMAND - TELBASE call minute/Year
projected demand - TELBASE call minute/Year


Utilization vs. Target - Telecoms
1
.85
.7
.55
.4
1985 1989 1993 1997 2001 2005 2009 2013
Time (Year)
capacity utilization - TELBASE 1
target utilization - TELBASE 1

There are some very substantial differences here between the airlines and telecoms. The airlines strive for higher capacity utilization over time, and this has an increasingly significant impact on their pricing and capacity retirements. By comparison the telecoms expect and accept much lower utilization during 1993-2010 than occurred in the late 1980s.

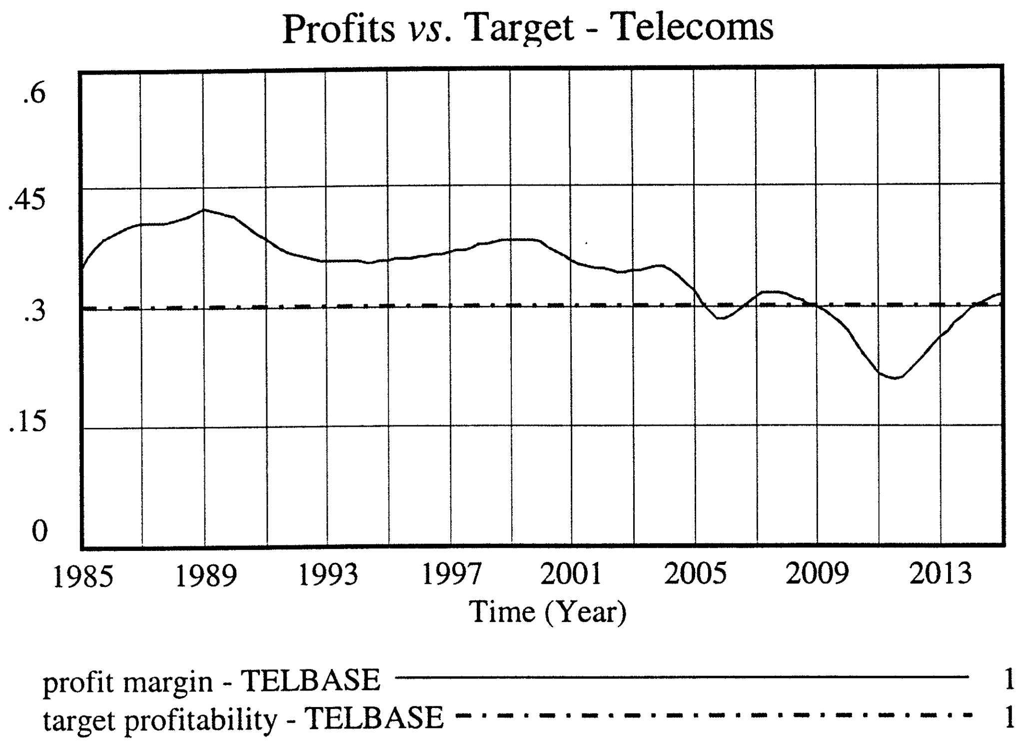


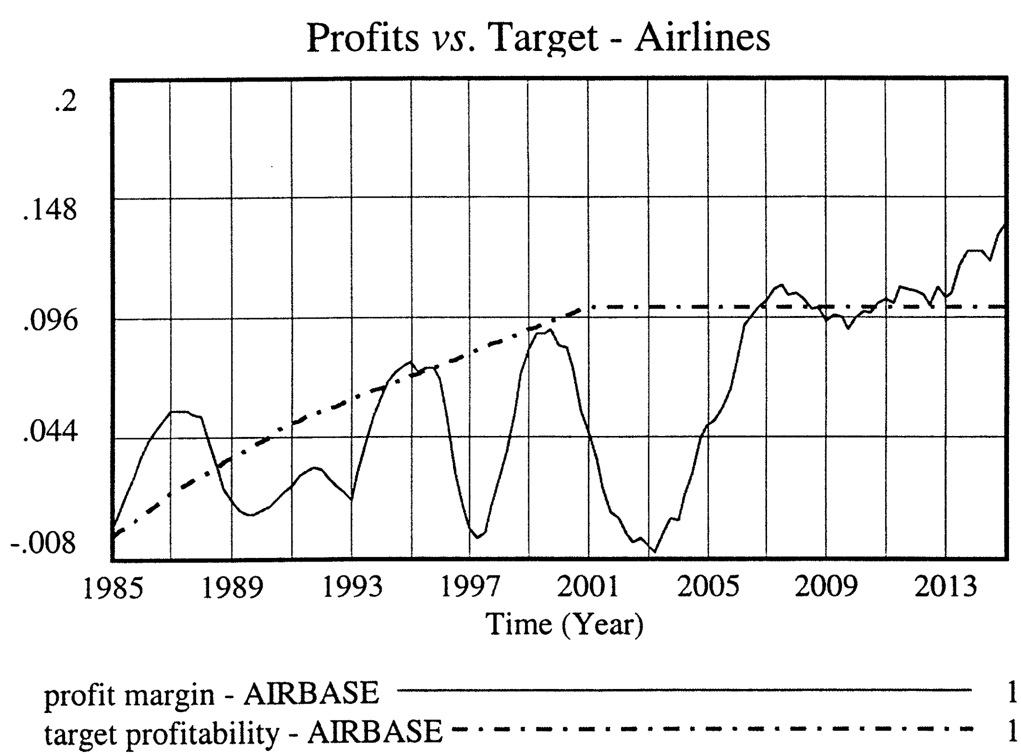
Profitability

Profit margin (i.e., operating profits/revenues) is reasonably stable from the mid-1990s through 2004, oscillating in the range of 35-38%. Margins then deteriorate significantly, falling to about 21% in 2011 before recovering.

Not surprisingly margins are quite satisfactory so long as unit costs are declining at least as fast as prices. But it is assumed that the rate of cost reduction slows dramatically starting in 2005, and local access costs become increasingly significant. This results in a decline in margins during 2004-11. They dip below the assumed target of 30% far enough to affect capacity decisions after 2012, but as described above the impact on pricing is negligible. Between 2012 and 2015 an upswing in demand growth and resulting improvement in capacity utilization push margins upward.

Unlike the airlines the long distance telecoms refrain from destructive utilization-driven price cutting until 2004. However when utilization pressures finally hit the telecoms' pricing the impacts are quite significant. Poor capacity utilization depress their prices by 13% in 2005 and 16% in 2011.



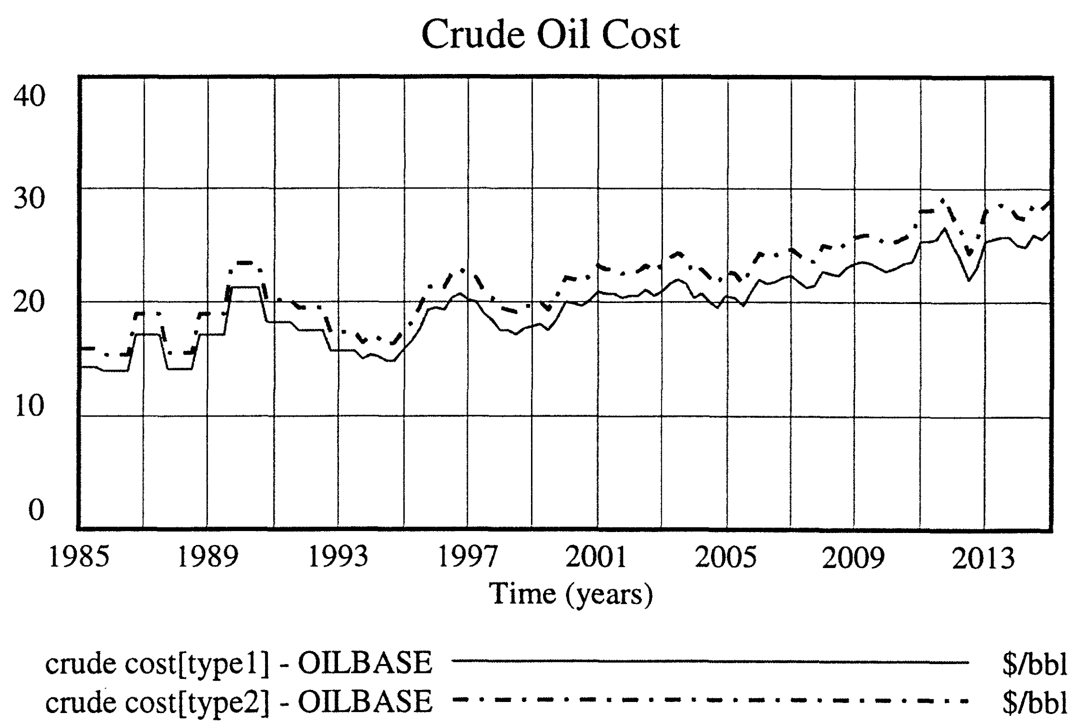


These profitability results reflect several fundamental differences between the two industries. For the telecoms new technology leads to dramatically lower costs and prices, which in turn stimulates rapid demand growth. Rapid demand growth soaks up what otherwise might of been excess capacity. And radically different mid-term capacity utilization expectations mean that the telecoms are much slower to perceive themselves as having "excess" capacity. The airlines by comparison are struggling to achieve their utilization and margin targets, equate high utilization with better profitability, and hence are far more prone to price wars.

Refined Petroleum Products

Base Case Assumptions

Feedstock (generally crude oil) is the largest cost of operating a refinery. For the period 1985-94 actual historical crude oil prices were used as inputs to the model. From 1995 onward the nominal price/barrel of crude oil is assumed to rise at an average rate of 2% p.a. Crude price cycles ±15% around this trend with a period of 6 years. The Base Case crude price also contains a random element for added realism. The more sophisticated refineries (called "type 1" in the model) with significant up-grading capabilities are assumed to use somewhat lower-priced feedstock than the less sophisticated refineries ("type 2"). Specifically feedstock costs of the type 1 refineries are 95% the average price of crude oil, while the type 2 refineries are 105%.



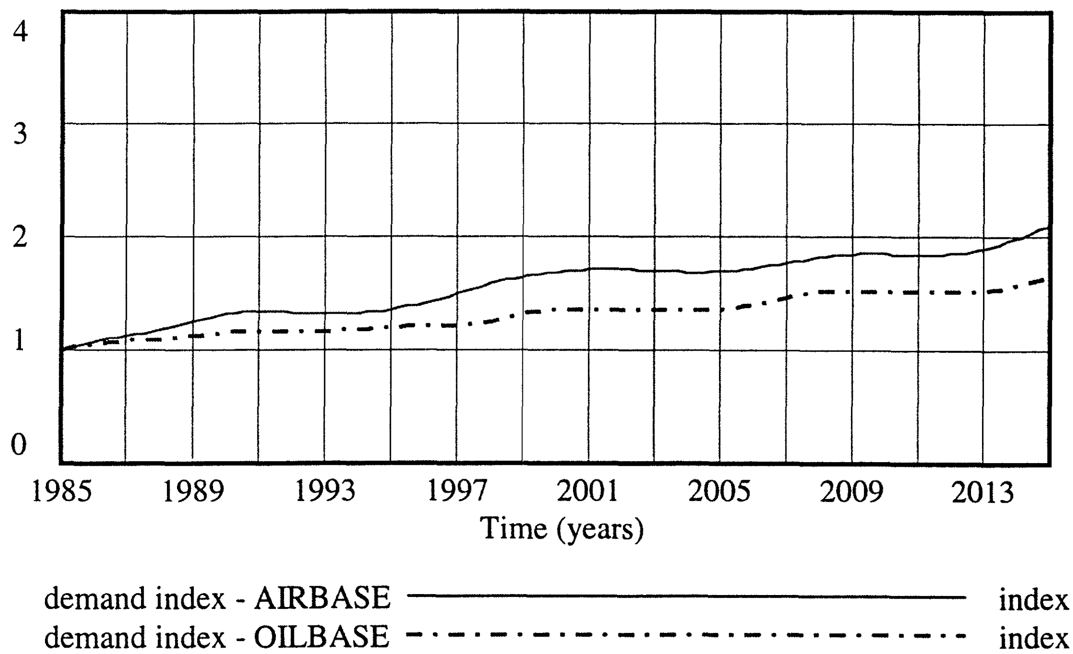
The refiners' desired capacity utilization is assumed to increase from 87% in 1985 to 95% in 1994, reflecting an attempt to improve profitability in reaction to a serious erosion of profit margins. The refiners' target profitability (expressed as the ratio of operating profits to revenues) is assumed to be constant over time at 0.1. This is the same as the airlines' long-term target margin but substantially below the telecoms' target of 0.3.

Demand

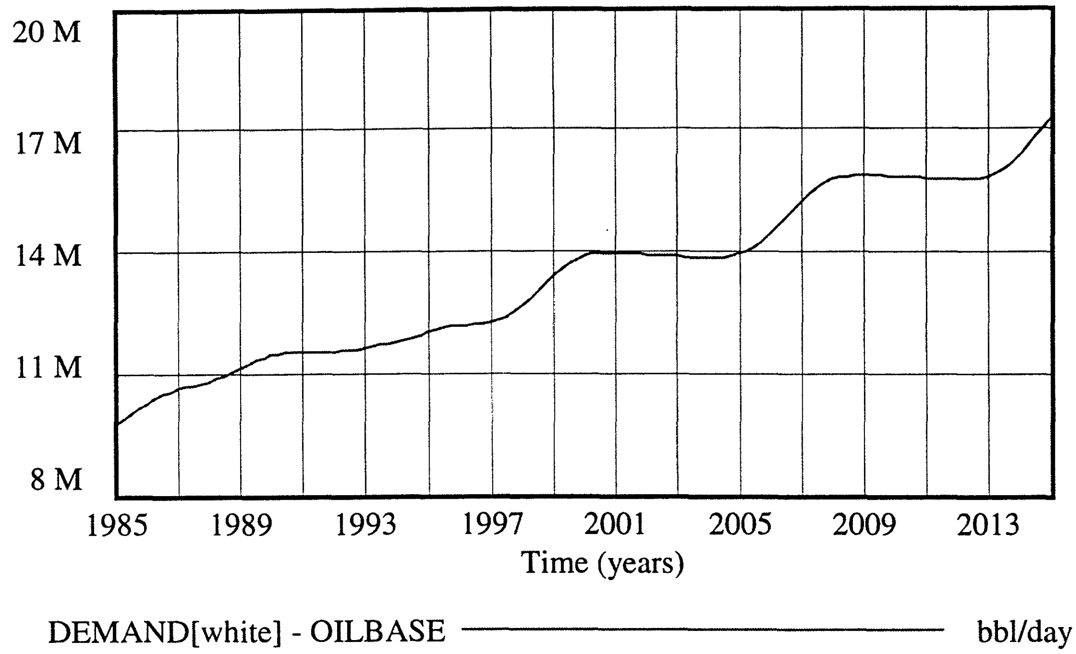
Once again demand growth is irregular, showing the classic "stair step" pattern. However the growth rate is significantly slower than for airlines or telecoms. Total demand for refined petroleum products grows at an average rate of about 1.7% p.a. during 1985-2015. The demand for "white" products (gasoline, jet fuel, and diesel) grows significantly faster than the demand for "black" products (heavy fuel oil for power plants and ship). The former grows at an average rate of 1.9% over the thirty year simulated period while the latter is essentially constant.

Demand for refined petroleum products is driven primarily by GDP growth. The mid-term price elasticity is quite low, i.e., -0.05 for "white" products, and the price trend for these products generally is upwards. As described above GDP growth is assumed to cycle around an average of 1.7% p.a. (between a maximum of 4.6% and a minimum of -1.2%). The GDP elasticity of demand is variable, dependent on GDP growth, and is above 1.0 when GDP growth itself is high. During 1997-2015 demand for "white" products grows slightly more than GDP. The demand elasticities in all three models were estimated from historical data.

Demand Index - Airlines and Refiners



Demand - *White* Products



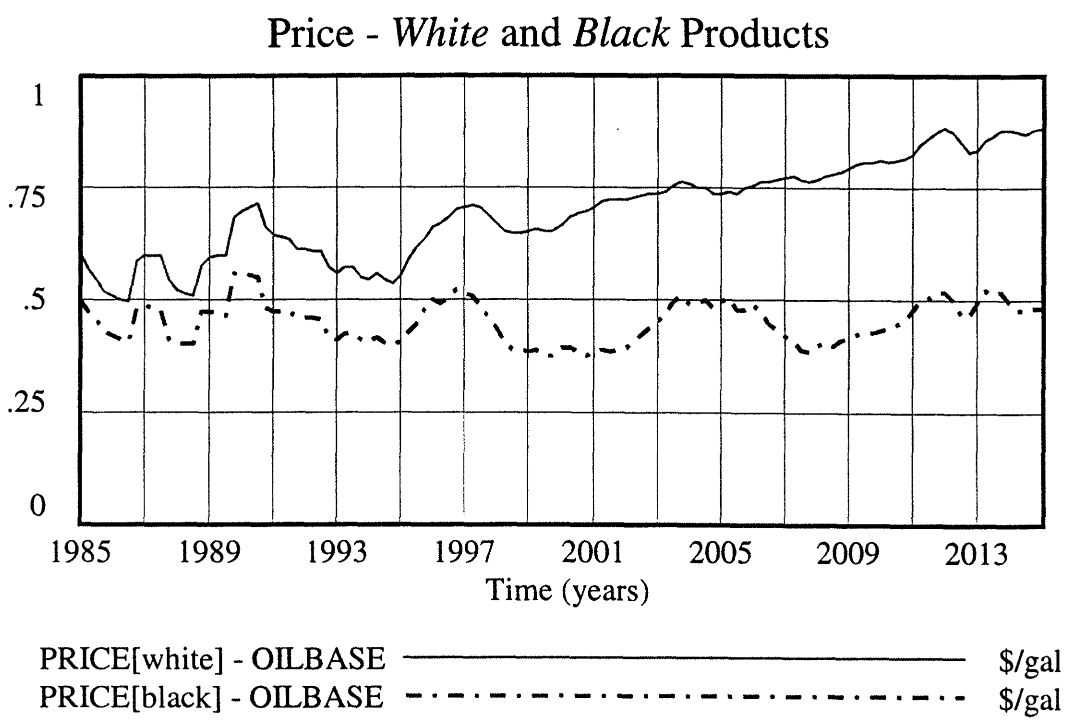
<u>Price</u>

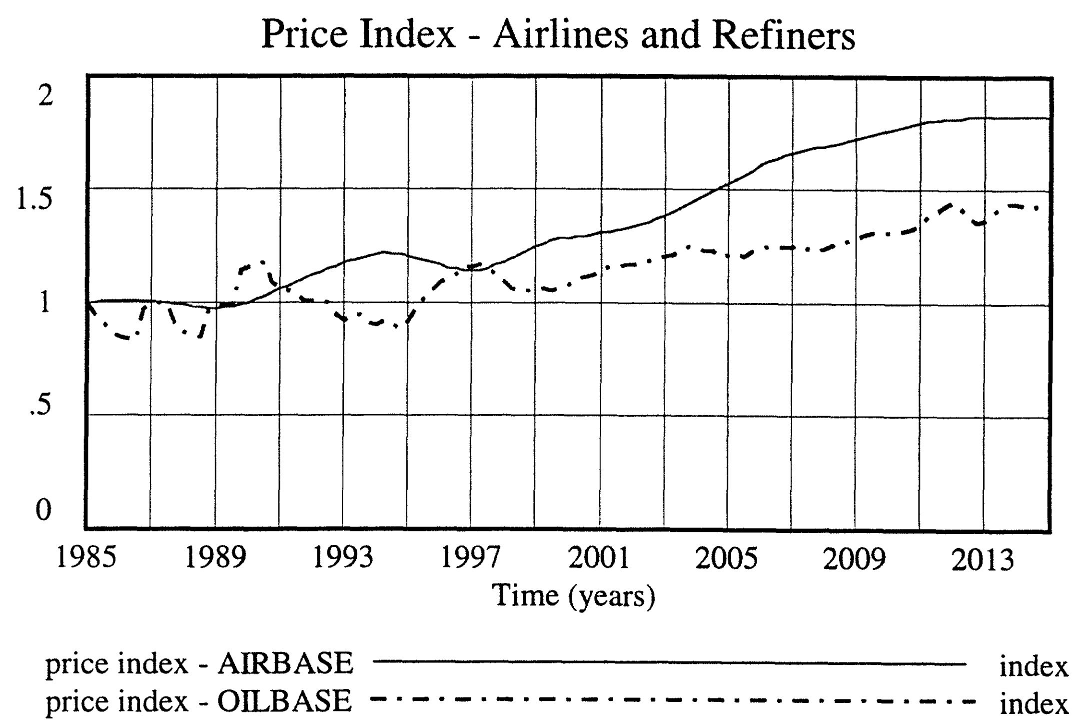
From 1995 onward the average price of refined petroleum products (in nominal, inflated terms) trends up, but with irregular oscillations that are different from the stair step pattern of demand. Between 1997-2015 this price rises at an average of 1.2% p.a. The price of "white" products rises more consistently than the price of "black" products, which is highly cyclical. The price difference between the two types of products is quite variable, ranging from as little as 20% to as much as 100%.

The price of "white" products is determined primarily by unit costs, which are dominated by the cost of crude oil (the principal refinery feedstock). The effects of capacity utilization and profitability are relatively minor.

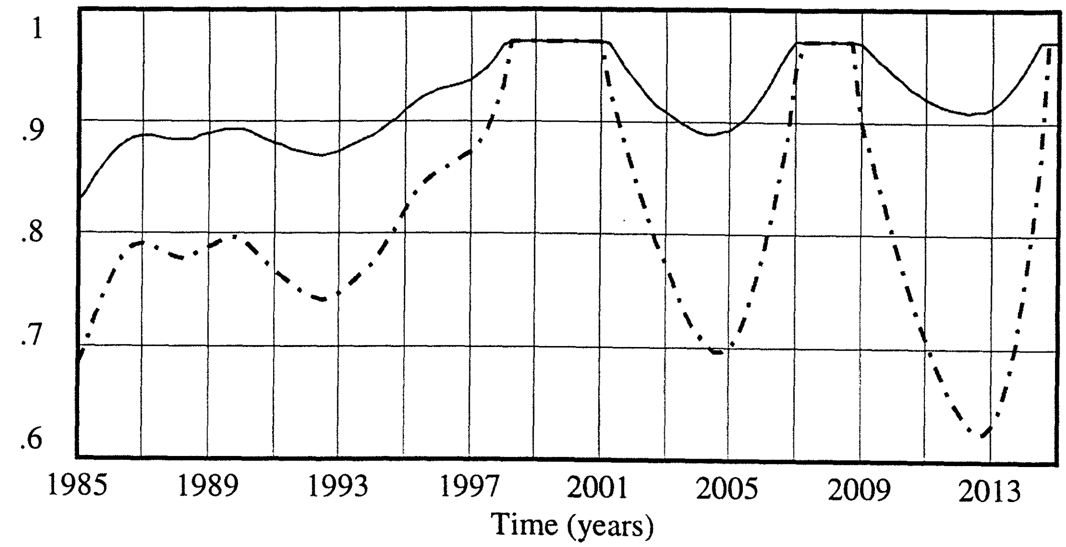
The pricing of "black" products is more complex. As explained above the demand for these products is approximately constant while the demand for "white" products is growing. "Black" products are the residual of the refining process, i.e., in order to satisfy the demand for "white" products a certain amount of "black" products also must be produced.

Most of the base demand for "white" products is covered by the more sophisticated refineries (so-called "type 1") with significant up-grading capabilities, i.e., they produce a high proportion of "white" output. However when the demand for "white" products steps up substantially as in 2005-07 more of the less sophisticated refineries ("type 2") also must be exploited. And these refineries produce a much higher fraction of "black" output. During such periods, e.g., 2008, "type 2" refineries are run near full capacity, and a substantial surplus of "black" product results. A high fraction of the "black" production must be exported. Hence the price of "black" products is cut to stimulate export demand.



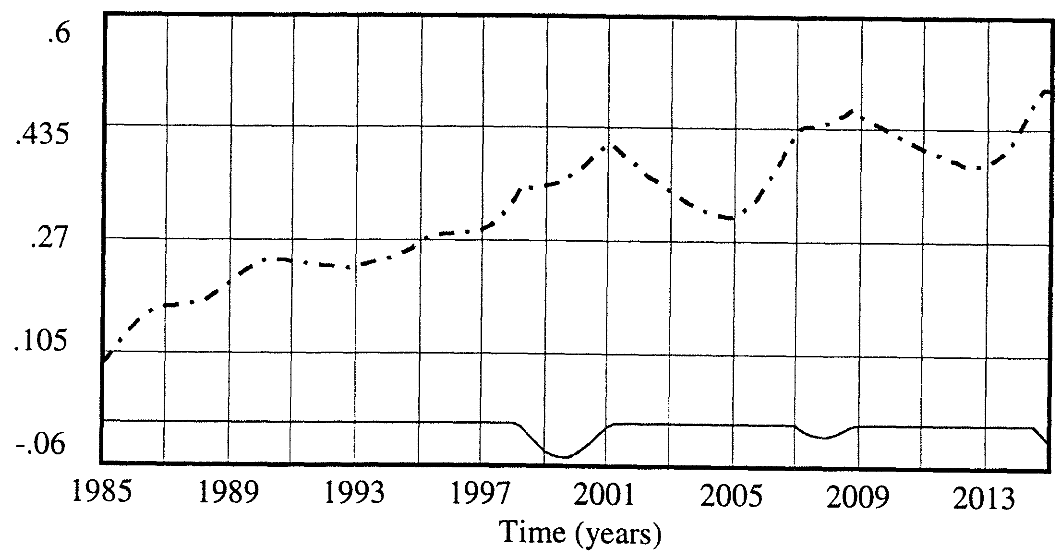


Capacity Utilization - *Type 1* and *Type 2*



capacity utilization[type1] - OILBASE ———————— fraction
capacity utilization[type2] - OILBASE -·-·-·-·-·-·-· fraction

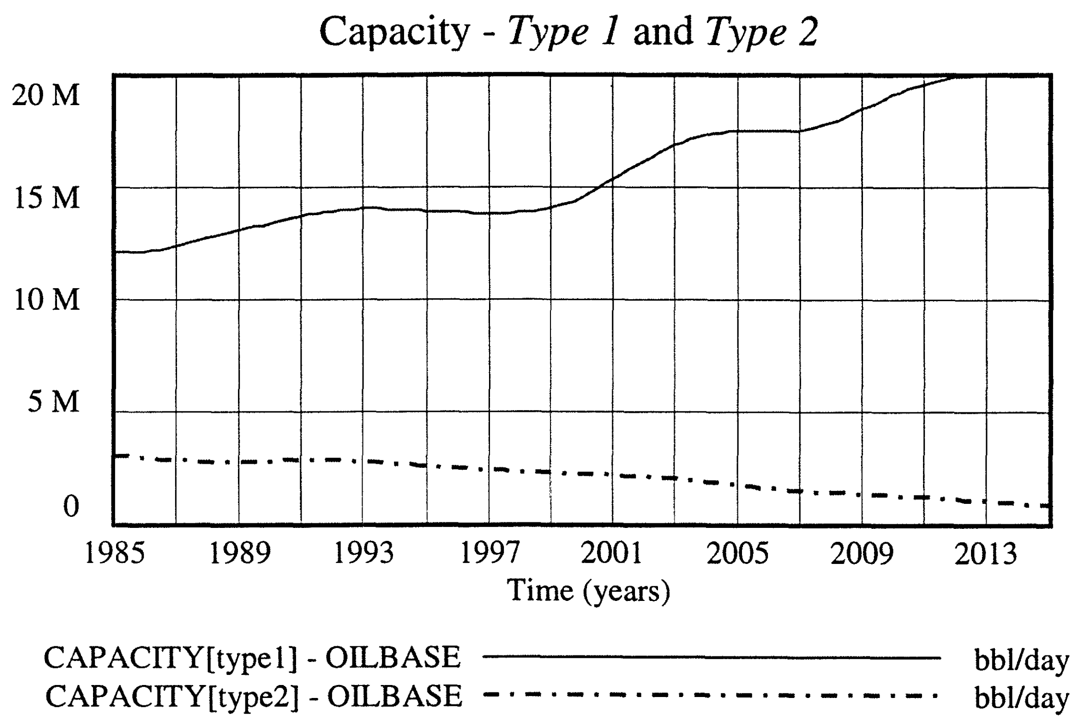
Export Fraction - *White* and *Black* Products



export fraction[white] - OILBASE ———————— dimensionles
export fraction[black] - OILBASE -·-·-·-·-·-·-· dimensionles

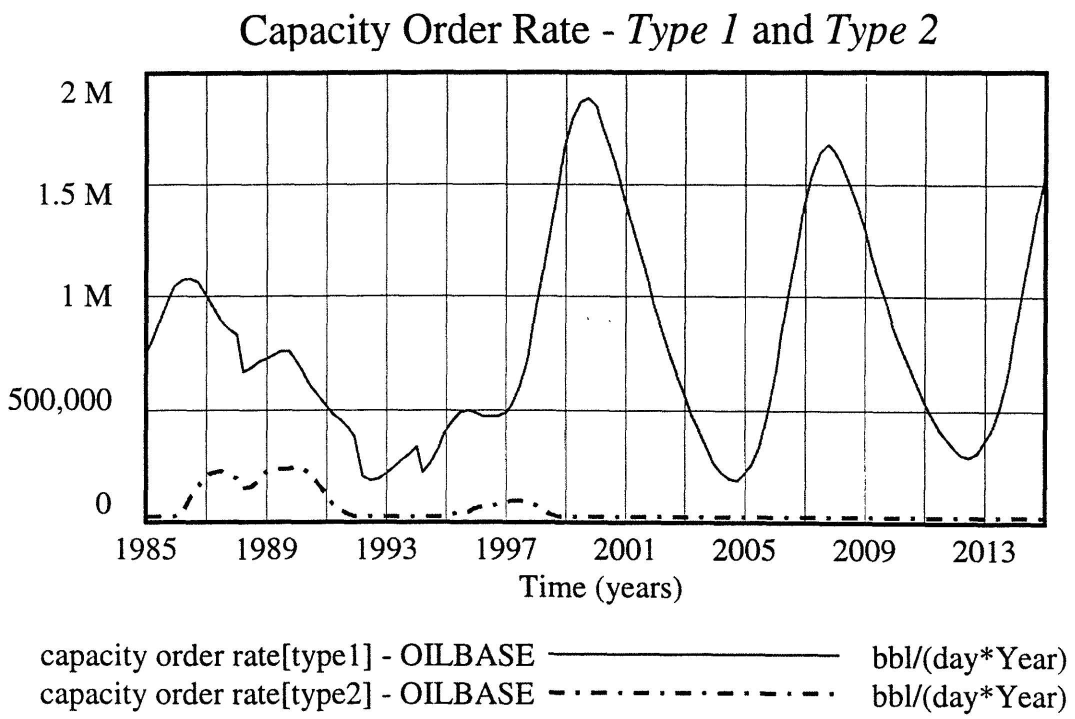
Capacity

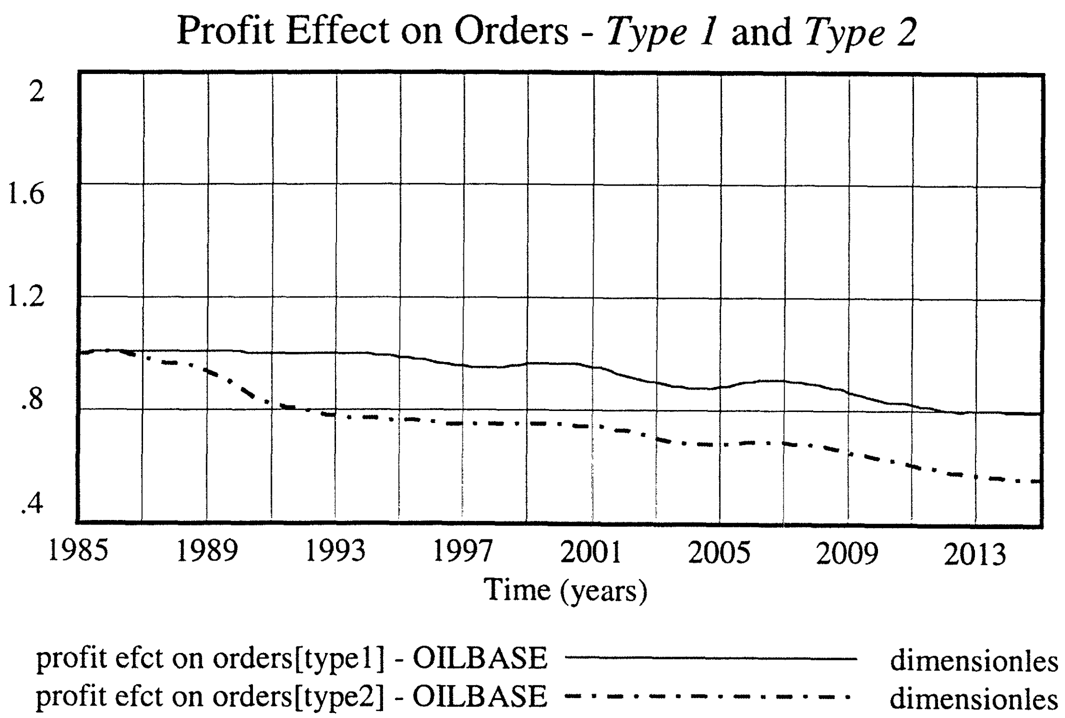
"Type 1" capacity grows steadily, following the "stair step" pattern of demand. "Type 2" capacity declines slowly from 1994 onward.



Capacity orders go through very severe cycles with peaks in 2000, 2008, and approximately 2016 (an eight year period). Orders collapse in 2001 and are extremely low during 2004-05. They recover slowly starting late 2005. By 2008 capacity orders reach almost 90% of the previous peak.

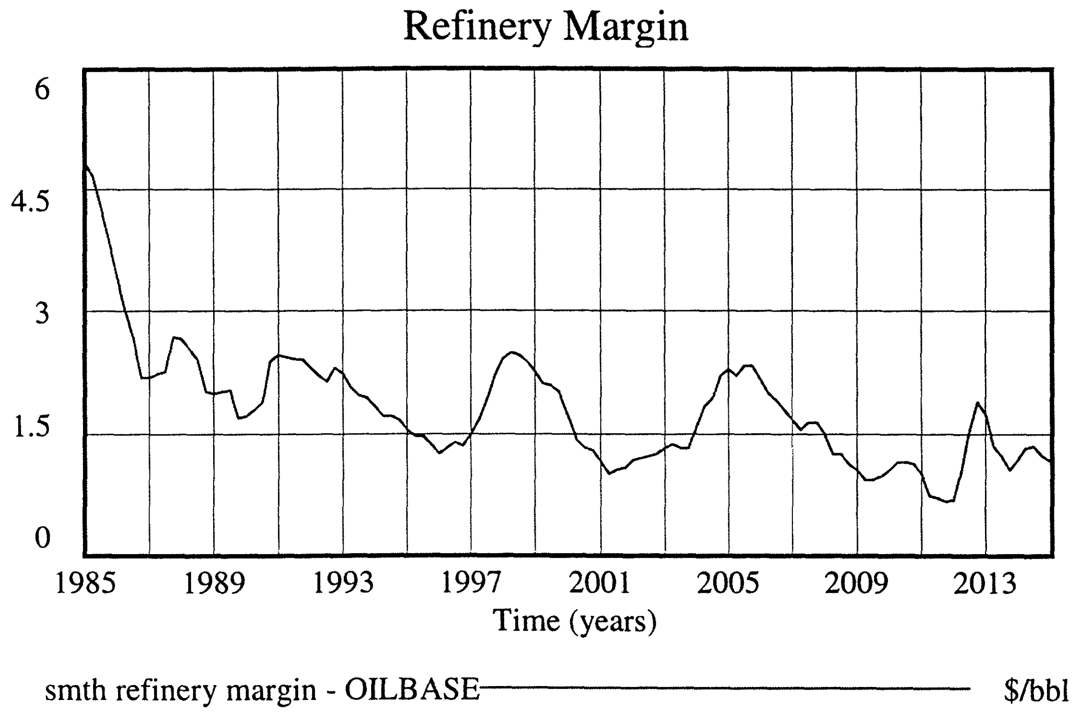
These cycles are cause by the combination of irregular demand growth for "white" products, highly variable capacity utilization, and deteriorating profitability. The latter effects are substantially more extreme in the case of "type 2" capacity than for "type 1." As described above "type 2" is the swing capacity. Poor profitability and periods of low utilization also cause pressures for accelerated capacity retirement of "type 2" capacity. During 2004-06 about 9% of this capacity is retired per year *vs.* about 4% p.a. normally. The refiners' preference for "type1" *vs.* "type 2" capacity depends on the relative prices of "white" and "black" products.


Capacity Order Rate - *Type 1* and *Type 2*
2 M
1.5 M
1 M
500,000
0
1985
1989
1993
1997
2001
2005
2009
2013
Time (years)
capacity order rate[type1] - OILBASE
bbl/(day*Year)
capacity order rate[type2] - OILBASE
bbl/(day*Year)


Profit Effect on Orders - *Type 1* and *Type 2*
2
1.6
1.2
.8
.4
1985
1989
1993
1997
2001
2005
2009
2013
Time (years)
profit efct on orders[type1] - OILBASE
dimensionles
profit efct on orders[type2] - OILBASE
dimensionles

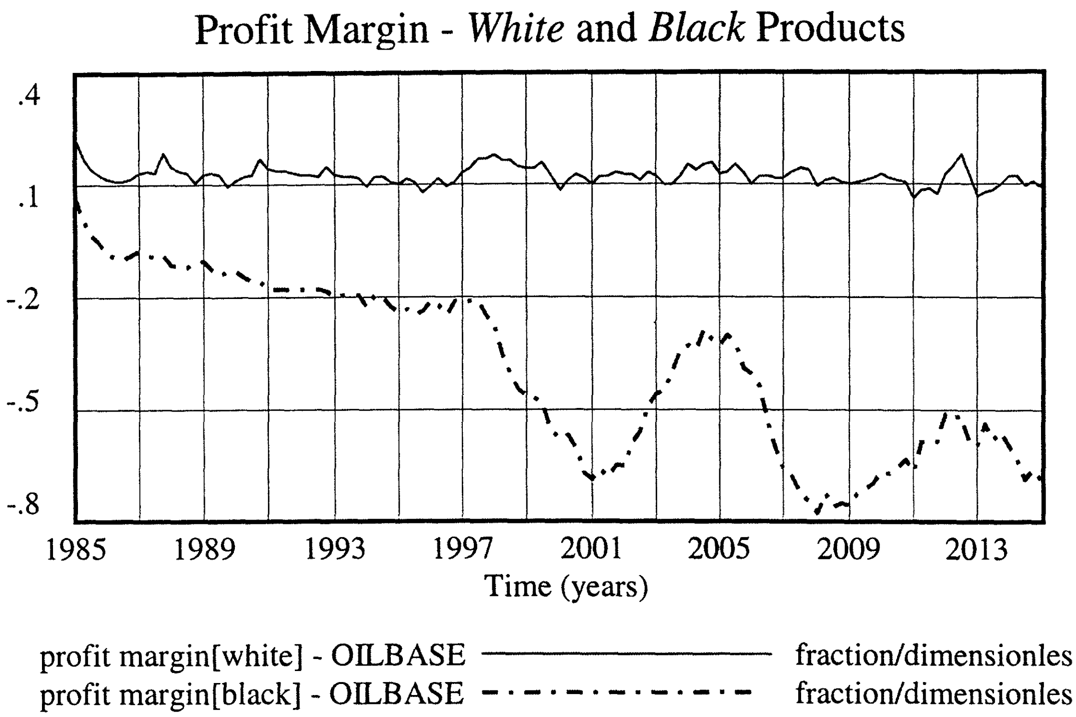
Profitability

The refining margin (i.e., operating profits/barrel) improves significantly from its 1996 trough and oscillates in the range of $1.00-2.40 between 1998 and 2005. Then margins erode to below $1.00 in 2011-12 and recover thereafter to almost $2.00.



Overall refining margins are satisfactory in periods where the profit margin on "black" products is at a cyclical high and poor when the "black" margin is at a cyclical low;. On a fully-costed basis "black" products have a negative margin. When there is a glut of "black" products and their price is cut to stimulate exports this negative margin is quite large.

While "white" product margins are positive and far more stable, swings in the "black" margin drive the overall profitability of refining. Each cycle the fraction of "black" product that must be exported rises, the gap between "white" and "black" product prices widens, and the swing in margins becomes more extreme. The average "black" margin erodes over the long-term.



Conclusions

The simulation results illuminate and explain a set of factors which drive commoditization. Confidence in these conclusions was enhanced by the combination of: (a) the generic model's ability to recreate the past behavior of three different markets and industries; (b) extensive review of the model's cause/effect structure with industry experts; (c) a detailed examination of the Base Case simulations to ensure that the underlying dynamics makes sense; and (d) sensitivity tests of key inputs and embedded assumptions.

Demand growth in commoditized markets tends to follow an irregular "stair step" pattern, driven by the combination of recurring cycles of over capacity and price cutting and macro-economic cycles. Demand growth typically slows as an industry matures. This is both a cause and result of commoditization. A point is reached where eroding margins produce pressures which counter-balance the downward effects of poor capacity utilization on price. Ambitious new entrants seeking to build share, established companies defending their positions, and even governments backing national champions all have their limits. The result is to moderate price cutting and thereby slow subsequent demand growth. As discussed above the effect of price on demand is least pronounced for refined petroleum products.

In commoditized markets the relationship between prices and costs is complex and highly dynamic. During periods of low capacity utilization intense competitive pressures appear to de-couple price from underlying costs. Strong competitive pressures cause less than 100% of any cost increase to be reflected in prices. Even when costs are declining significantly competitive pressures can drive prices down faster and farther.

The effects of technology on the industry's cost structure also are significant. If, as in the case of the airlines, the investment required per unit of capacity is rising the industry becomes dominated by fixed costs. This makes margins extremely sensitive to capacity utilization, and hence increasingly volatile. Conversely, as with telecoms during most of the simulated period, if technology is driving fixed costs down steadily, margins become less sensitive to utilization and in general more stable.

Capacity orders tend to become increasingly cyclical over time, with the down-cycles becoming lower and more extended. This has profound implications for both the industries in question and their suppliers. Highly commoditized industries will have periodic opportunities to introduce new technologies, but these will be quite limited both in duration and relative to the installed base of capacity.

Suppliers will face an increasingly severe "feast or famine" marketplace. They will find it extremely difficult to maintain their production and technological capabilities during the periods of famine and to accurately anticipate the next feeding frenzy of orders. Thus suppliers are likely to become risk averse and reactive, waiting until the next cycle is clearly underway before expanding capacity and launching new development programs. In that case lengthy delivery delays, serious quality problems, and slowly evolving technology are the probable results. This is the situation currently facing major parts of the commercial aircraft industry.

The combination of slowing demand growth, eroding profitability, and inherently long asset lifetimes (generally 20-30 years in the industries studied) leads to stagnation of the industry's portfolio of capacity. There are powerful incentives in a commoditized industry to stretch asset lives and invest as little as possible. Significant "barriers to exit" which make it more difficult and/or costly to eliminate capacity (e.g., governmental support of national champions, protection by bankruptcy courts, or environmental regulations which impose large clean-up obligations) exacerbate those dynamics.

While the model does not explicitly track technology, the implication is quite clear: any new technologies are adopted very slowly. The outcome is a perverse technological lock-in. Technologies which offer the possibility of moderating or escaping from the commodity game have a small impact. The research indicates that this is a crucial part of the advanced stages of commoditization. Industries, at least in their traditional forms, become trapped in a commodity business from which escape is increasingly unlikely.

These results support the overarching conclusion that commoditization is driven by excess capacity. And they show that complex interactions over time among industry structure (e.g., the fragmentation and internationalization of markets), management policies (e.g., the response of pricing and investment decisions to capacity utilization and profitability), and technology strategy (e.g., the impacts of technology on costs and capabilities) underlie persistent excess capacity and, hence, commoditization.

The results also raise significant questions about cause and effect. As described above commoditized industries generally are characterized by mature technologies and little innovation. But is this the consequence of commoditization? Does commoditization erode and eventually destroy the incentives and capabilities to innovate? Or is commoditization the result of inadequate investment in technology and innovation? The same questions can be asked about the high proportion of fixed costs in most commoditized industries. Does this cause commoditization by exaggerating the difference between marginal and average cost? Or is it the effect of pursuing economies of scale in a market with razor thin margins?

The research shows that these factors are ***both*** causes and effects of commoditization. The same is true for the tendency in commoditized industries to add capacity in ever larger blocks, and for there to be inadequate supplier capacity and hence exaggerated lead times during each up-cycle in capital investment.

Moreover the research suggests that companies in highly commoditized industries are over-valued by financial markets. It is quite likely that financial markets, not fully understanding the dynamics of commoditization and their consequences, are overly optimistic about the "quality" (i.e., the growth and volatility) of these companies' future profits. Adequate profitability tends to be limited to periods of substantial, but not sustainable, cost reduction.

Future profitability depends on: (a) where a company stands in the long-term dynamics of commoditization; (b) how rapidly those dynamics are moving; and (c) the effectiveness of its management in understanding the dynamics and then defining and implementing appropriate strategies. The investigation of strategic responses for corporations contending with commoditization is not yet complete. A subsequent report, "Winning Strategies in Commoditized Markets," will present conclusions from analyses of optimal pricing and capacity investment policies under various market conditions. It will be completed over the next 3-4 months. A preview of the emerging conclusions is contained in a video-taped presentation available on request from ICRMOT.

The results to date also illuminate factors which slow commoditization. While the generic model represents the industry, not the individual firm, these conclusions have significant implications for corporate strategy.

Rapid market growth mitigates commoditization. It does so by quickly absorbing any excess capacity which might develop from over-optimistic forecasts, industry fragmentation, or subordination of profitability to building and defending market share. Thus it reduces the importance of the barriers to exit which typify commoditized markets and otherwise cause excess capacity, once it develops, to persist.

With rapid market growth planning errors are forgiven. And a rapidly growing market is less of a zero-sum game for new entrants. They have greater possibilities to build volume without directly confronting the incumbents. There is more opportunity space for new entrants and incumbents to co-exist. This moderates the conflict among their objectives and the resulting price competition. Rapid market growth substantially reduces the likelihood that excess capacity will compound from one industry cycle to the next.

Technological progress also is very important in mitigating commoditization. New technologies offer possibilities for differentiation, for example, supersonic travel, wireless Internet access, less-polluting fuels, fully integrated financial services. Technology-driven enhancements in product and service capabilities can stimulate faster demand growth. Consider the impact of the Internet on demand for telecommunication services. Less-polluting fuels may prevent regulatory constraints on energy consumption. And as note above, more rapid demand growth absorbs excess capacity more quickly.

In addition significant new technology can reward aggressive investors with a combination of lower costs, lower capital intensity, higher value added, and greater operating flexibility than their less aggressive competitors. This is particularly apparent in the telecommunications industry. By comparison the petroleum refiners are very cautious exploiters of new technology. The results raise a provocative conclusion. "Commoditization" easily can be a state of mind. In that case it inevitably becomes ***a self-fulfilling prophesy!***